FLOOD MONITORING USING AUTOMATIC PACKET REPORTING SYSTEM APRS ON VHF

by

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16336

Dissertation submitted is partial fulfilment of the requirements for the
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CERTIFICATION OF APPROVAL

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Approved by,

____

(AP DR MOHD NOH BIN KARSITI)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

CERTIFICATION OF ORIGINALITY

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

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WAN MOHD FARID BIN WAN SARIS

ABSTRACT

Flooding is a one of the devastating natural treat towards Malaysian which can cause a loss of life, money and property. Due to great damages to residential area, agriculture land, roadways and buildings, government have to spent a lot of money to recover all the damages which can affect the economy of the country. Therefore, in order to deal with this problem, one of the system can be improved is in the early warning flood detection system based on real time basis. This paper presents the prototype design of a flood monitoring system which build by combining the water level sensor (conductance probe sensor) , monitoring LCD display, VHF 2m band handheld transceiver Baofeng UV-5R, Open Tracker USB terminal node controller board (APRS decoder), Arduino microcontroller and GPS module as a field station equipment (transmitter) at the catchment area while TPlink MR3020 internet modem, computer, RTL-SDR vhf tuner and another handheld radio transceiver as a monitoring station equipment (receiver). This real time monitoring system is developed to monitor the changes of water level and send an alert to user via an APRS network immediately whenever a system defined alert condition initiating. The ability to receive real time information on flood level empower both government and private organisation to react to the imminent danger in an effective approach. With the real time flood information, allows public safety organisations and other emergency managers to effectively plan their resource deployment within the time of alert. This system is cost effective and provides efficient data measurement where the user can easily monitor the level of water based on location that have high possibility to hit by flood by looking at the APRS server.

ACKNOWLEDGEMENT

I would like to gladly express my deepest gratitude and appreciation to a number of people who contributed and supported to the success of this final year project.

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TABLE OF CONTENT

TABLE OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

APRS	- Automatic packet reporting system
AFSK	- Audio frequency shift keying
TNC	- Terminal node controller
AX.25	- Data link layer protocol for packet transmission
HDLC	- High level data link control
VHF	- Very high frequency (30MHz - 300MHz)
DAQ	- Data acquisition
SKMM	- Suruhanjaya Komunikasi & Multimedia Malaysia
MCMC	- Malaysian Communication & Multimedia Commission
RAE	- Radio amateur examination
I-GATE	- Internet Gateway
Transceiver	- Combination of transmitter and receiver device
Baofeng UV-5R	- Handheld Transceiver
aprs.fi	- Open source APRS web server
Decoder	- Circuit use to convert data into a set of signals
Amplifier	- Device use to amplify the power of signal
DAB	- Digital Audio Broadcasting
FM	- Frequency modulation
SDR	- Software Defined Radio
DID	- Department of Irrigation & Drainage

Chapter 1: INTRODUCTION

1.1 Background Study

A flood monitoring system consolidates device for recording and collecting the reading of an instrument (for this case would be the water level data or rainfall data) and transmitting the data via radio signal, then the device will be placed at the selected locations around the catchment area. Recently, flood disaster in Central Kelantan, Perak, Terengganu and Pahang had been triggered by rising river water level and continuous rainfall. This phenomenon is considered as norm since Malaysia is situated near the equator which the climate is hot and humid throughout the year and rainfall occurs throughout the year too. Flood disaster often causes damages and loss of life and money due to improper and unreliable early flood detection system.

Flood monitoring using Amateur Packet Radio System on VHF, provides low power serial formatted data packet frames AX.25 radio transmission and equipped with reliable touch/conductance sensor. This complete system will do self-monitoring by detecting the warning water level that have high possibility for flood hit which will create a serial data flood data and decoded by Open Tracker to send as audio tone frequency shift keying in the AX.25 protocol for transmitting. The water level and amount of precipitation could be monitored to provide real-time feedback for advanced warning system and prediction.

1.2 Problem Statement

Nowadays, the flood monitoring system in Malaysia are still using manual monitoring that need a number of people to standby near to the catchment area, for instance, the river and update the condition there to the local authorities. If there is a sign of flood will hit that area, then the monitoring people will ask the local residents to evacuate to the safer place. However this method would be a problem if there is a lack of resource in term of people to monitor all the catchment area and also the limited accessibility to the place. Other method used is by using helicopter to monitor the area which is not a cost effective , limited monitoring view and take a lot of time to monitoring each catchment area. Thus, the only way to counter the problem is by setting up the autonomous flood monitoring system with the reliable data transmission.

In order to monitor and predict the flooding situation, a self contained low cost water level monitoring device using modified water level sensor connected to microcontroller need to be developed and tested. The flood measurement data is to be sent as a packet burst using 2 meter VHF transmitter to the monitoring station via APRS channel frequency. The monitoring station would need to developed real-time monitoring and condition modelling for decision.

1.3 Objectives

Flood monitoring using Automatic Packet Reporting System on VHF is a solution to early flood detection monitoring system which provide real time monitoring and reliable flood transmission data which integrated with the location by the GPS. The objectives of this project are to design, develop and test:

1) A self-contained low cost water level monitoring device using water level sensor measurement technique.

2) A communication system using packet burst on 2 meter VHF from APRS transmitter to the monitor station.
3) A real-time monitoring and condition modelling software.

1.4 Scope of Study

The scope of study for this project are :

- To study the suitable and reliable water level monitor system.
  Water level monitoring system has to be constructed to automatically respond to the occurrence of water rising. Several conditions need to be considered in order to trigger the sensor.

- To learn about the amateur packet radio system (APRS) :
  The working principle of APRS should be understand first before knowing how to interact that with the microcontroller. Moreover, the hardware and component that needed to built an APRS should be identified and studied for designing a prototype device. To make a transmission on APRS channel frequency, the student must have a amateur radio license. RAE, radio amateur examination by MCMC / SKMM must be taken first before handling the project that use certain channel frequency which has been stated in Malaysia communication law.

- To understand the working principle of radio packet data, Terminal node controller and AX.25 protocol.
  AX.25 is the communication protocol implement in packet radio, which basically the standard of 2 computer or microcontroller communicate to each other. Terminal node controller is the hardware which function as packet dissambler or assembler packet AX.25 data. Deeper study on those element need to be done in order to built an APRS prototype.

Chapter 2: LITERATURE REVIEW

2.1 Flood Monitoring and Early Warning System In Malaysia

Flood forecasting and warning system in Malaysia organizes an essential and economical approach to reduce loss of lives and property damage. Since 1971, Department of Irrigation & Drainage, DID, has been designated with the task of providing flood forecasting and warning services to the public residents. Based on records show that this organization provided the service for flood event of 1925 that occurred along the Kinta River, Perak and Klang River , Selangor and also at Bernam River at boundary of Selangor & Perak. In 1900's, flood monitoring system based on water river levels stage gauge was set up at Bradley Steps, Kuala Krai, Kelantan. The police who standby there, help in providing water level reading and transmitted it via VHF sets to the Flood Warning & Relief Committee in Kota Bharu. [1]

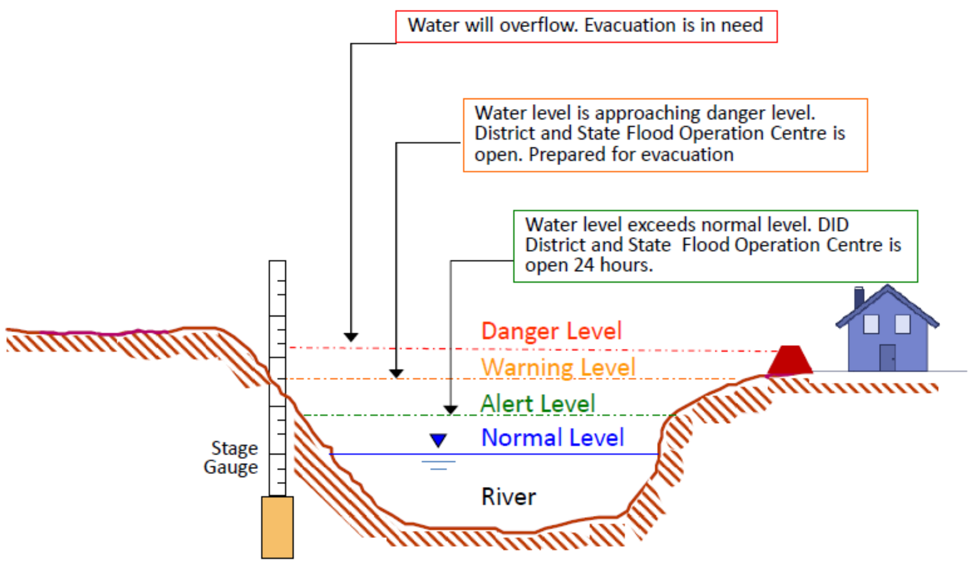


Figure 1 Stage gauge water level monitoring

2.2 Automatic Packet Reporting System (APRS)

"M.Mayers state that APRS is an abbreviation or shortened form for Automatic Packet Reporting System, and is a system method of transmit digital data wirelessly in the form of packet radio[1]. ""Packet Radio is a digital radio communications mode". "It uses the same theoretical concepts of data transmission via Datagram that are fundamentally to communications via the Internet, as opposed to the older techniques used by dedicated or switched circuits Morse Code"[1] .D.Akins mentioned that based on those old concepts, packet was purposeful as a way to reliably transmit written information digital data. The predominant advantage was initially anticipated to be increased in speed, but as the protocol developed, other capabilities also improved "[2]."Tanya Deller cited, it was designed in the early 90's, but it has seen development in the last few years due to user-friendly software such as WinAPRS or UI-View, and Kenwood Baofeng APRS enabled radio transceivers becoming available" [4].

D.Akins mentioned that the APRS technology was a jump forward, making it possible for almost all packet station to act as a digipeater, linking distant stations with each other through ad hoc networks. This makes packet transmission very useful for emergency and urgent communications. Plus, mobile packet radio stations can automatically transmit their latitude longitude location by program it or by using gps module, and check in periodically with the APRS network to show that they are still operating[2].

D.Akins mentioned that the most common use of packet is in amateur radio, to construct wireless computer networks. Packet radio uses the AX.25 (Amateur X.25) data link layer protocol, derived from the X.25 protocol standard and adapted for amateur radio use. AX.25 was developed in the 1970s and is based on the wired network protocol X.25. AX.25 includes a digipeater field to allow other stations to automatically repeat packets to extend the range of transmitters. One advantage is that every packet sent contains the sender's and recipient's amateur radio call sign, thus providing station identification with every transmission.[2].

2.3 Terminal Node Controller (TNC)

W.S. Ford mentioned that in theory, a TNC works as a "radio modem". TNC function as intermediary between radio tranceiver and controller. It carry the data from computer or microcontroller, construct packets data in AX.25 protocol and then transforms the packet data into audio signals (audio frequency shift keying) for transmission by the radio tranceiver. Conversely, on other APRS station side , the TNC demodulates the received AFSK signal, decoded it back into data, deconstruct the AX.25 packets and sends the finished data to microcontroller. [5].

W.S. Ford mentioned that for 300 and 1200-baud applications, TNCs create signals for transmission using audio frequency shift keying(AFSK). Twelve hundred baud packet is most common and is used primarily at VHF. When creating a 1200-baudsignal, a *mark* or 1 bit is represented by a frequency of1200 Hz. A *space* or 0 bit is represented by a frequency of2200 Hz. The transition between each successive mark or space waveform happens at a rate of 1200 baud. The frequencies of 1200 and 2200 Hz fit within the standard narrowband FM audio passband used for voice, so AFSKis accomplished by simply generating 1200 and 2200 Hztones and feeding them into the microphone input of astandard FM voice transmitter [5].

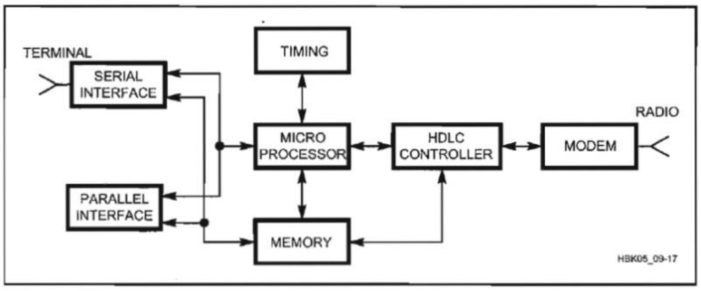


Figure 2 Functional Block Diagram of a standard TNC board

W.Steve Ford stated that a functional block diagram of a standard TNC board is revised in the figure above. TNC contain a serial data interfacing connect to a dumb terminal. Eventually, the terminal is a microcontroller or complete developed computer. Then, Data transmit to the computer or microcontroller and tranmit inversly via this terminal. At the brain of the TNC is the microcontroller and the present of HDLC, High level Data Link Controller. The microcontroller is the intelligence component of the unit which control the unit, but the HDLC is in charge for constructing and deconstructing the AX.25 protocol packet data. The modem is obviously a signal wave modulator (convert packet data to audio signal) and demodulator (convert audio signal back to packet data) [5].

2.4 VHF (Very High Frequency) Radio Transceiver

W.S. Ford mentioned that VHF handheld radio is a two way radio which a radio that can transmit and receive radio signal. This Device used together with TNC to built an APRS. 1200 baud packet tones can be fed directly into the microphone input of any VHF FM voice transceiver. To connect the radio and TNC, program cable would be needed by custom build the cable .In most cases, there are separate connections for the audio input and the push-to-talk (PTT) line. (The TNC grounds the PTT line to key the transceiver.) Some transceivers also make receive audio available at the microphone jack for use with speaker/microphone combos, then canuse this line to feed audio to the TNC [5].

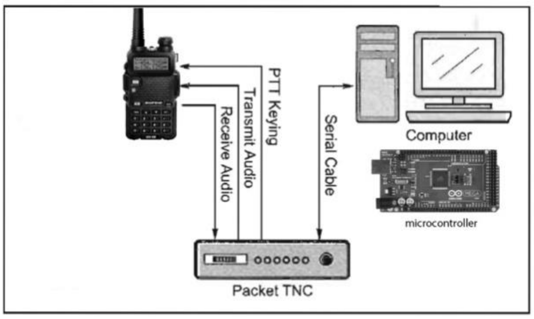


Figure 3 TNC interface to the microcontroller through an RS-232 serial cable

2.5 Repeaters (digipeater) & IGATE

A.E. Loring mentioned that in telecommunications, a repeater is a network hardware device that receives a signal and retransmits it at a higher level or higher power, or onto the other side of an obstruction, so that the signal can cover longer distances. It is a generic term that refers to several different types of devices; a telephone repeater is an amplifier in a telephone line, an optical repeater is an optoelectronic circuit that amplifies the light beam in a optical fiber cable; and a radio repeater is a radio receiver and transmitter that retransmits a radio signal. A broadcast relay station performs an analogous role in broadcast radio and television.[5]

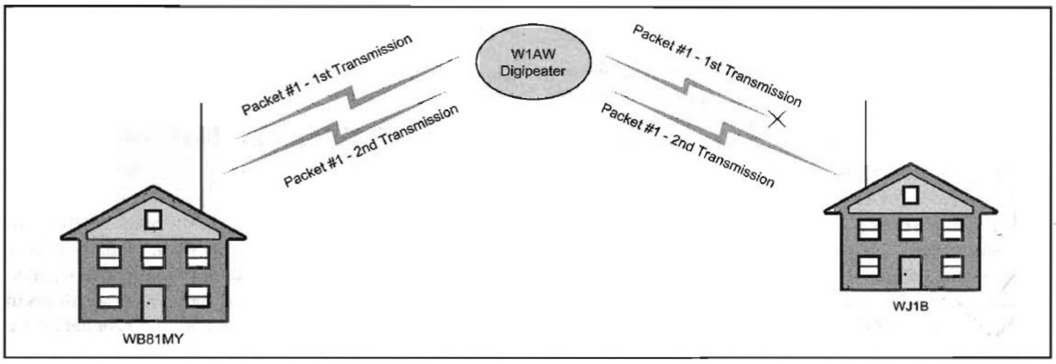


Figure 4 Digipeater bounds the received signal to other receiver.

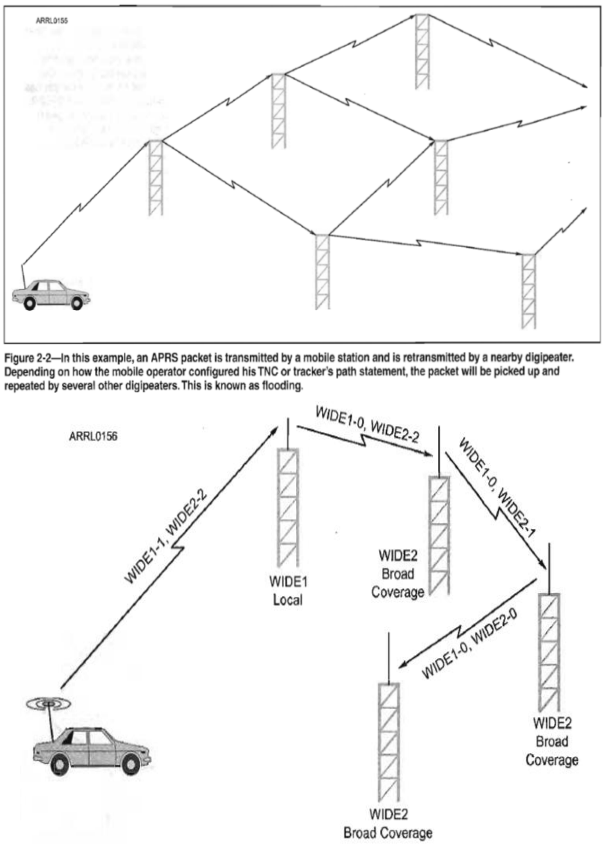


Figure 5 How command WIDE 2-2 works on repeaters.

A.E. Loring stated that a repeater is an electronic tools in a communication system device that add up the power of a data signal and retransmits it back, allowing the signal to travel at further distance. A high amount of electric resource power is needed to amplifies the signal. A radio repeater usually consolidates of a radio receiver to receive the signal and connected to a radio transmitter which is to transmit back the amplifies signal. Usage of a duplexer can allow the repeater to use one antenna for both receive and transmit at the same time. For this project repeater that will build is called as digipeater. Digipeater a repeater node station in a APRS radio network. It performs a store and forward function, passing on packets of information from one node to another.[5]

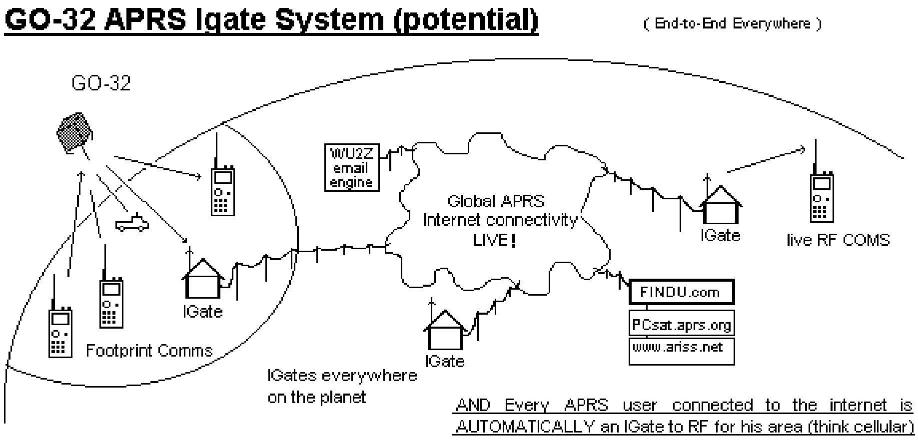


Figure 6 I-Gate send the radio packet data to global via internet connectivity

W.S. Ford mentioned that the APRS network is not a continuous VHF or UHF system stretching from coast to coast and border to border. There are gaps in coverage where one subset of the network is isolated from the rest. Fortunately, APRS uses the internet to act as a bridge between the areas, unifying the network nationwide. [5]

W.S. Ford cited that digipeater in APRS can be modified to become Internet Gateways, IGATE. IGate digipeater stations work with dedicated software and hardware that upload all received APRS packets and to open source APRS internet servers. IGate is configured depends on how the owner set it up, packet is bounced to another station and packets also uploaded to local networks from distant locations as a two way process. [5]

2.6 Water level Sensor For Flood Monitoring

There are 2 type of sensor that can be considered, ultrasonic sensor and conductance/touch sensor (probe). Water level conductance probe can be design accordance with the water's physical properties of having a weak electrical conductivity. In fact, the conductance probe was designed by using a low corrosive metal wire and pipe. One end of the wire was tied with the ground pin of the main circuit board; the other end was submerged into the water.

The metal wire pin is a stainless needle which was fixed on the sliding rule of the optical water scale placed in the pipe to form a probe assembly. When the probe (one of the pin) touched the water surface, the resistance between the metal pin and the GND (wire) was between a few hundred KΩ increase to few MΩ; but when the probe separated from the water surface, the resistance between the probe and GND was open. Thus, the water level could be detected based on the value of the resistivity [7].

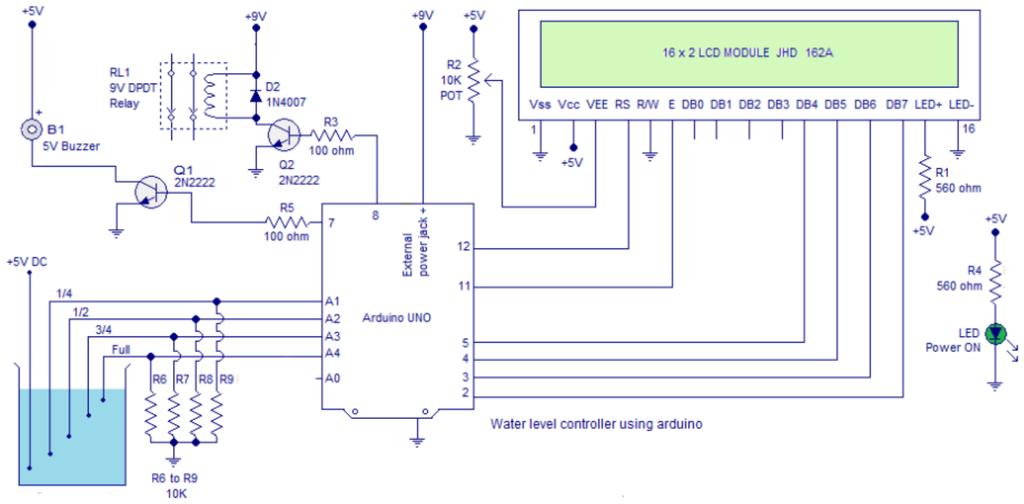


Figure 7 Circuit Diagram of conductance sensor with microcontroller.

HC-SR04 is the ultrasonic ranging module for water level testing . HC-SR04 consists of an ultrasonic transmitter, receiver and necessary electronics for making it a standalone system. The operating principle is very simple. It sends 8 pulses of 40KHz sound waves, and picks up the reflected wave. The time lag between the transmission and reception is measured and the distance is calculated from the equation D=TS/2. Where D is the distance, T is the time lag and S is the speed of sound. The output of the HC-SR04 will be a pulse whose width is proportional to the distance. From the datasheet, width of the output signal will be 58uS for a distance of 1cm. What we need to do is to just send a 10uS wide trigger signal to the trigger pin of the module and wait for the output pulse at the echo pin of the module [8].

However, due to disturbance from bubbles, wave and heavy foam, this sensor is not really reliable compared to water probe sensor.

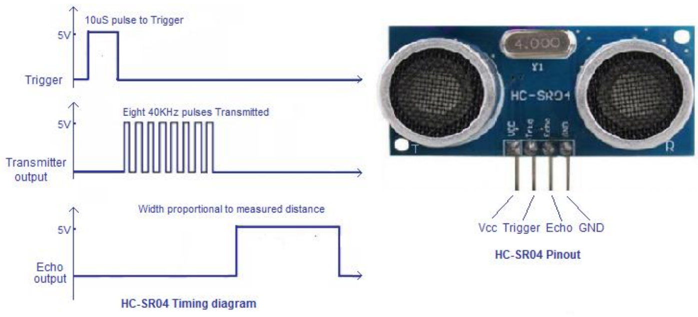


Figure 8 Timing Graph Diagram Ultrasonic Sensor

Chapter 3: METHODOLOGY / PROJECT WORK

3.1 Project Activities

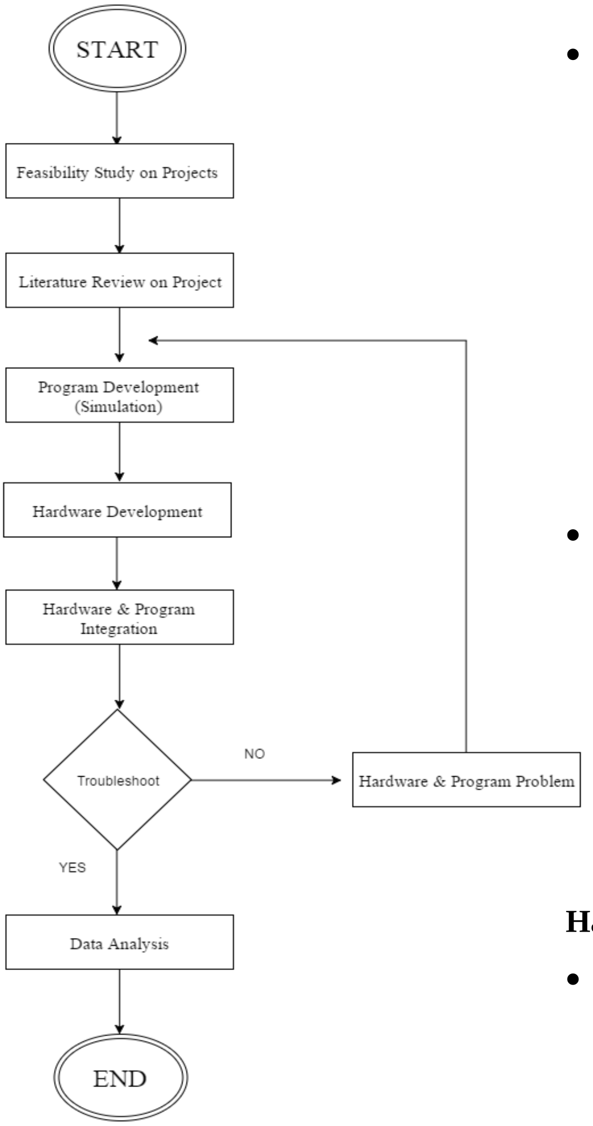


Figure 9 FYP Flowchart

FEASIBILITY STUDY

- Test and identify the reliability of the water level sensor. In this case, there are 2 proposed sensor for water level sensor which are ultrasonic sensor and touch/conductance sensor for measuring water level and raindrop volume. Those sensor will be connected with uploaded program microcontroller and can see the result through computer or LCD display.

- Study on Amateur Packet Radio System which cover the AX.25 protocol and terminal node controller hardware. Student need to study how TNC formatting flood data into AX.25 packets ,modulate it into audio signal and transmit it through VHF radio.

Hardware & Software Development

- Student has been expected to start build the prototype in fyp1. Basic system on flood monitoring and TNC should be develop first and get them ready for the troubleshoot period.

3.2 Research Methodology

1. Project topic selection and approval from the supervisor
2. Problem identification, develop objectives.
3. Advance study and do research on APRS & water level sensor
4. Selecting a suitable water level sensor
5. Data and information gathered from research.
6. Designing of prototype and constructing relevant circuit design
7. Develop list of equipments, hardware, code and alternatives
8. Prototype circuit build and uploading code
9. Evaluation and improvement of the prototype
10. Project Completed

Figure 10 Methodology & steps

3.3 Key Milestone FYP 1

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Secure FYP Title														
2	Literature Review Study														
3	Extended proposal submission						30\10								
4	Proposal defence & progress evaluation									18\11					
5	Project work														
6	Interim draft report submission													17\12	
7	Final report submission														24\12

Table 1 Key Milestone FYP 1

3.4 Gantt Chart FYP 1

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Title Confirmation														
2	Early Research on Project (Literature)														
3	Preparing Extended Proposal														
4	Prepare/buy the hardware & component														
5	Testing Handheld tranceiver														
6	Setup basic APRS system														
7	Proposal Defence														
8	Build flood moinitoring system circuit														
9	Interface APRS & flood monitor circuit														
10	Microcontoller algorithm and program														
11	Preparing Interim Draft Report														
12	Preparing Final Report														

Table 2 Gantt Chart FYP 1

3.5 Key Milestone FYP 2

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Study W	Final
1	Progress Report								9/3								
2	ELECTREX											30/3					
3	Draft Final Report (hardcopy)													11/4			
4	Final Report & Technical Paper														18/4		
5	Viva															25/4	
6	Final Report (Hard Cover)																25/5

Table 3 Key Milestone FYP 2

3.6 Gantt Chart FYP 2

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Testing Handheld tranceiver														
2	Setup basic APRS system														
3	Build flood moinitoring system circuit														
4	Interface APRS & flood monitor circuit														
5	Microcontoller algorithm and program														
6	Progress Report														
7	ELECTREX														
8	Draft Final Report (hardcopy)														
9	Final Report & Technical Paper														

Table 4 Gantt Chart FYP 2

3.7 Component & Functionality

Figure 11 Components & Hardware

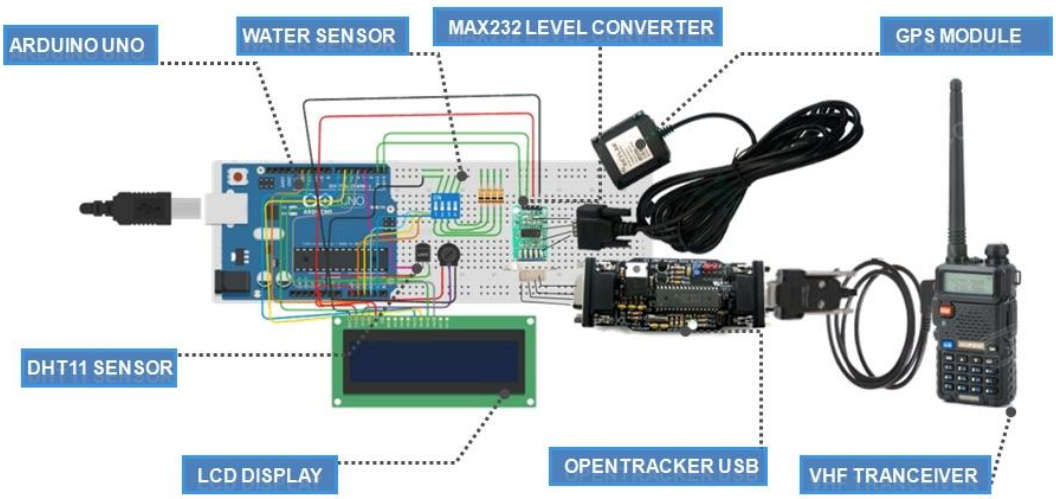


Figure 12 Hardware Configuration Connection Diagram

Basically, this project would require microcontroller, terminal node controller, VHF Radio, water level sensor, LCD display and a number of specific cables. Student decided to use Arduino as microcontroller. Microcontroller is one device that embedded with microprocessor and other electrical component which will act as head or brain for the prototype. Microcontroller will give command, read or write data from sensor and control other attached device by programming algorithm. There are analogue and digital pins connection as I/O pin which can be used to connect to the water level sensor, LCD display and alarm (if necessary). TX/RX pin will be used to connect to the RS232 terminal cable connection. In this project also student need to study and identified which is the most reliable water level sensor, then, the proposed sensor are touch/conductance sensor and ultrasonic sensor.

Terminal Node Controller will be connected from TX/RX pin by using RS232 converter, cable and null modem. OpenTracker USB will be the selected TNC. TNC connects to VHF radio transmitter and Arduino. Data from Arduino is formatted into AX.25 packet and modulated into audio signal which ready to be submitted. Those hardware will be used on the field and on the other site (station), the same hardware would be used but there will be no sensor and microcontroller will be changed to computer. On the main station, TPlink MR3020 modem is modify and connect to opentracker board (TNC) and VHF. Main station will be set up as IGATE Digipeater which can connect to the internet for data sharing. The field station is powered up by battery bank and will recharge during a day time by a solar panel. RTL-SDR is added to the monitoring station which interface with AFSK 1200 Decoder and sound modem card in the computer to heard and decode APRS packet data tone

3.8 Software& Application Tool

PLX-DAQ : Interpretation data of sensors connected to arduino and real-time data sensor monitoring, produces simple spreadsheet interpretation &analysis of data gathered in the field station.

Arduino IDE: To write and upload the programming codes for the arduino microcontroller

Otwincfg (Opentracker windows configure): setup the open tracker setting and configuration.

Openwrt: Setup the TPLINK modem for APRS IGATE main station. (web server base)

LTspice: To build a circuit based on simulation technique and analyzing the circuit schematics.

UZ7HO Sound Modem: Software Packet-Radio TNC that uses a soundcard as a modem and supports AX.25 protocol. The software Packet-Radio TNC uses the AGW Packet Engine API and emulates the AGW Packet Engine (TCP/IP interface).

SDRsharp : Software defined radio based on radio transceiver that used with the RTL-SDR USB dongle to monitor the signal wave data.

AFSK 1200 Decoder: software that used to decode APRS packet data received by the RTL-SDR

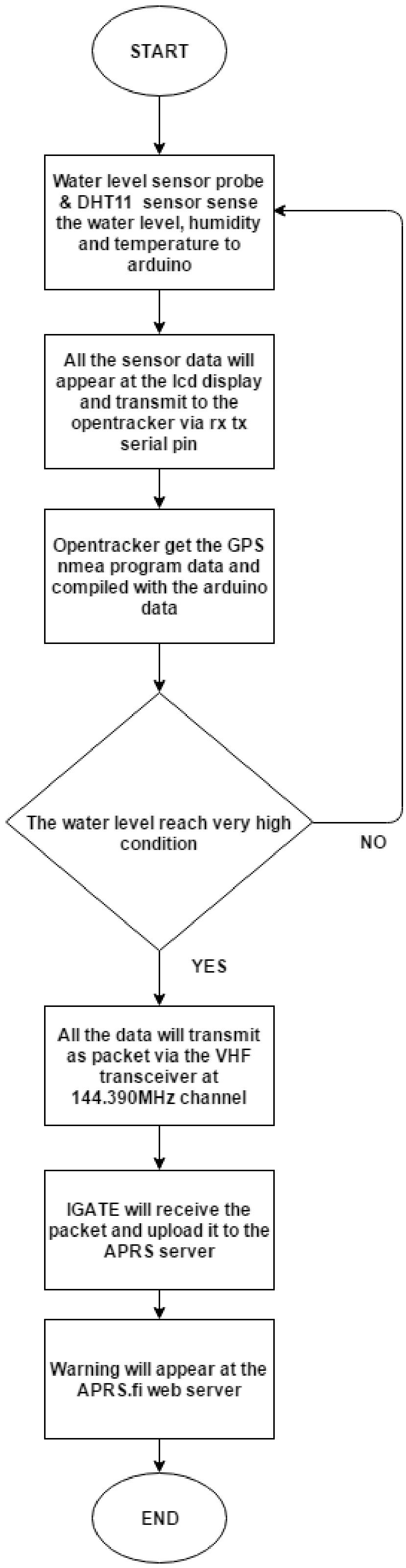


Figure 13 Programming Flowchart

*Refer the appendix 1 for the whole program.

Chapter 4: RESULT & DISCUSSION

4.1 Project Progress

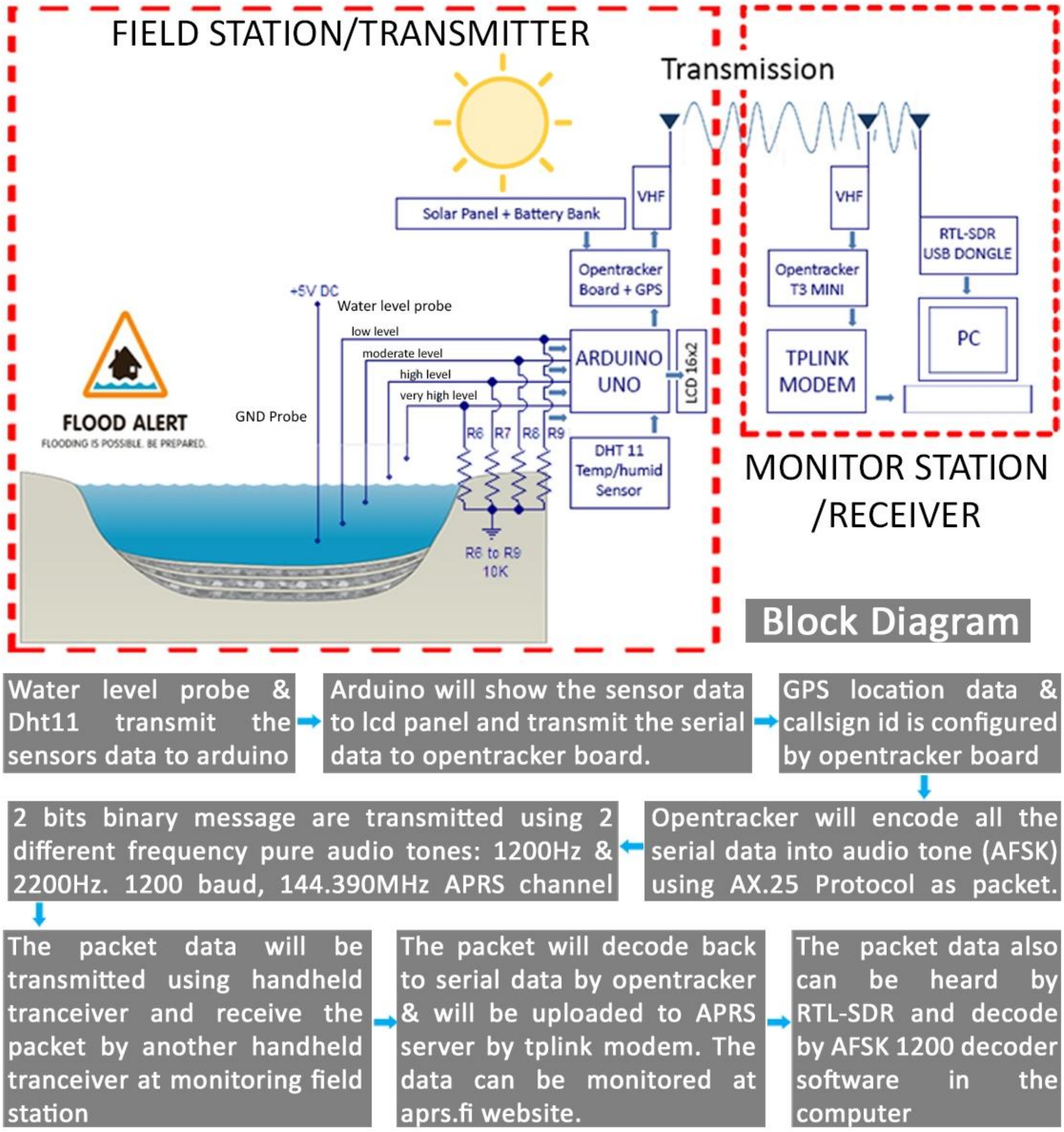


Figure 14 Model diagram sketch

Overall, from week 1 until week 27, most of the subsystem has been integrated which are the APRS field station, APRS I-Gate digipeater station (monitoring station) and also the water level monitoring system. There are humidity and temperature sensor added in the water level monitoring system. Thus the field station will transmit the packet data that contain the water level reading, GPS location, humidity percentage and the temperature value to the I-Gate monitoring station. However those prototype still not tested for the maximum radio transmission distance can be achieved. Prototype just been tested in the laboratory.

For the next progress activity, prototype will be fully assembled and tested on the field such as at the river. The VHF handheld should handle the transmission range around 3 to 5 miles. That will be varies due to surrounding condition, for instance the field location near to hills or valley. The field station is powered by rechargeable battery and will be charge automatically by solar panel during the day.

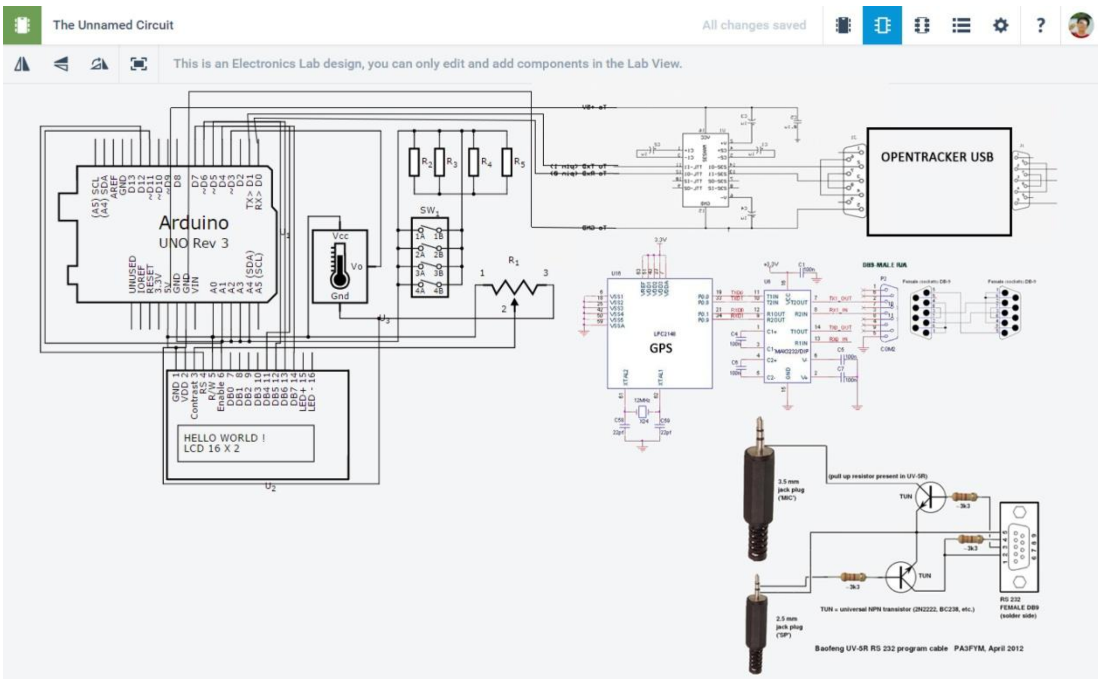


Figure 15 Schematics Diagram for Field Station

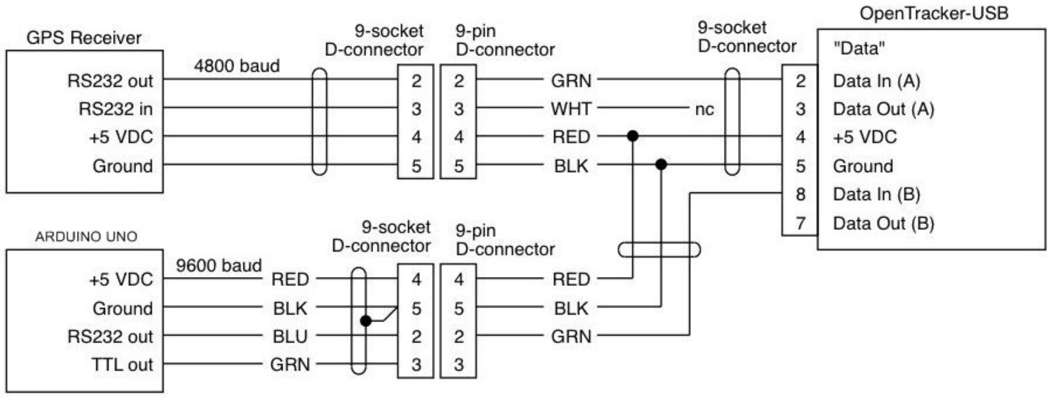


Figure 16 GPS receiver and arduino to opentracker connection

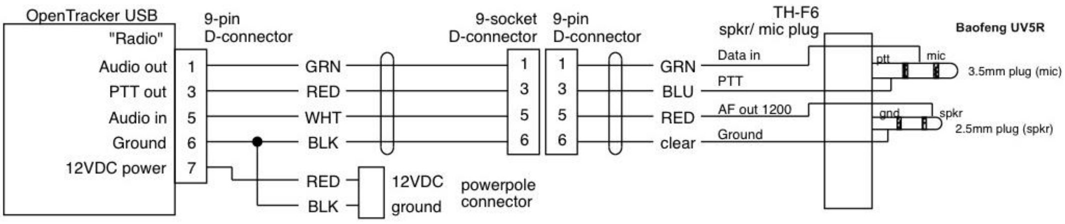


Figure 17 Baofeng VHF transceiver and opentracker connection diagram

4.1.1 Set up basic APRS station (field station)

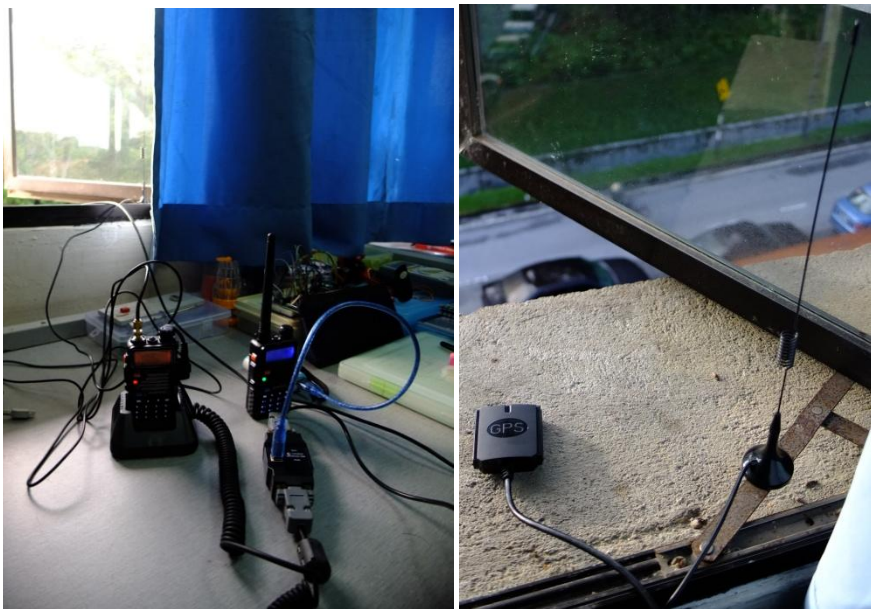


Figure 18 Set up connection for APRS field station

APRS field was set up by doing the wire connection from VHF handheld transceiver to Opentracker USB which have been configure through the program Otwincfg (Opentracker windows configuration). GPS module also been used and connected to opentracker USB. 23cm antenna is used and replaced the built in antenna.

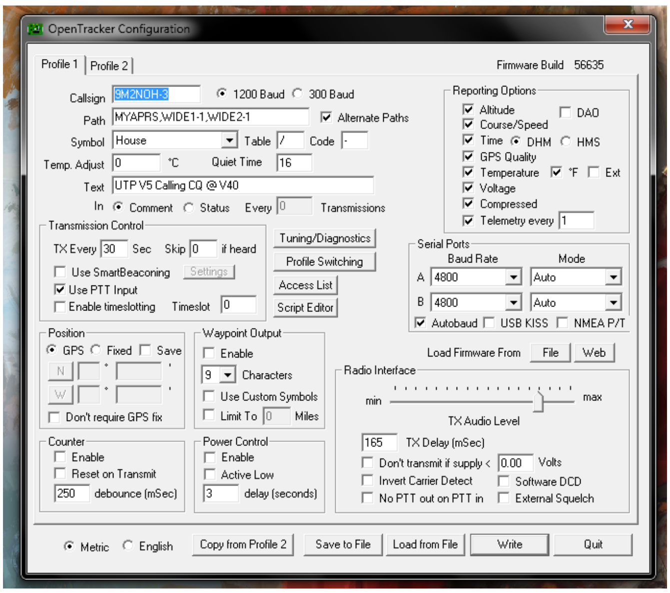


Figure 19 Opentracker Configuration

Figure 20 VHF transceiver is set at APRS channel 144.390MHz

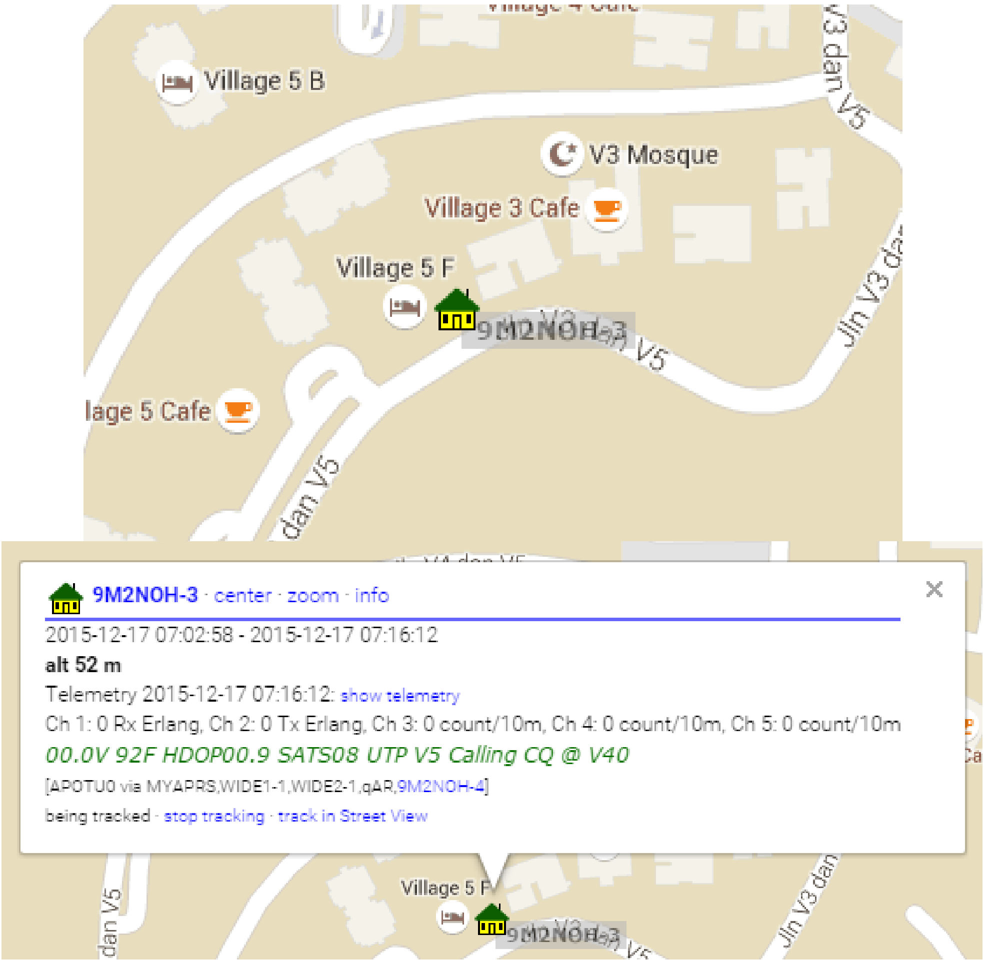


Figure 21 Monitoring using aprs.fi website

4.1.2 Set up basic APRS I-GATE System (monitoring station)

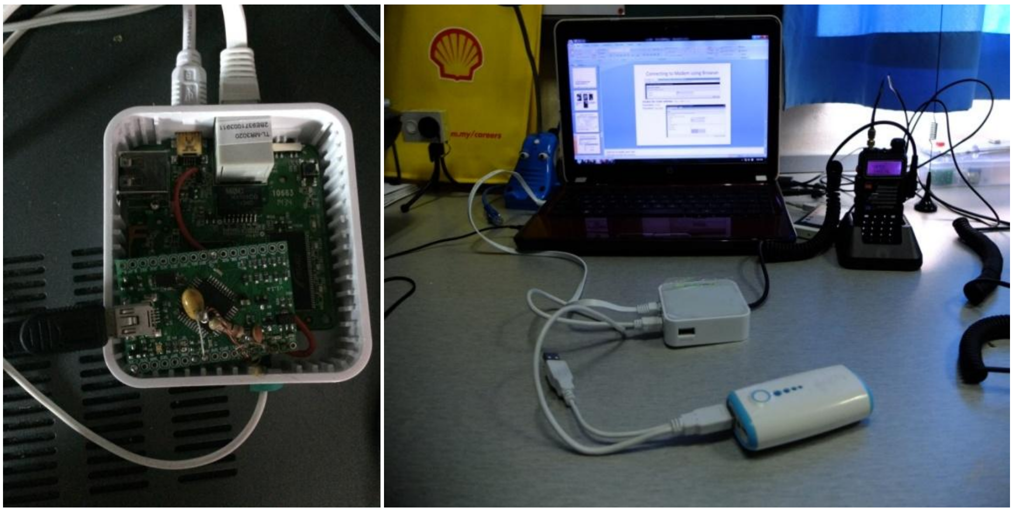


Figure 22 Set up connection for APRS I-GATE

Tools:

A new TP-Link MR-3220 modem casing is opened and connect the rx and tx pin to the Opentracker 3 mini (OT3 mini).

LAN 5e CAT is used for ethernet connection from TP-link MR3020 to the computer to setup the internet connection on the tplink server. PuTTY, (to telnet and ssh to the box) is used to program tplink modem boatloader. OpenWrt Firmware need to upload to the tplink modem for server ip address configuration.

Hardware Installation:

Ethernet cable is used to plug the WAN port of the MR3020 to one of the LAN port on router. The other LAN port on the MR3020 is plugged to the computer. Network configuration in WINSCP software must be set as DHCP. Connect the TPlink box with power source via USB cable. From here, internet access can be check by browsing the internet on the computer.

Firmware Change to OpenWrt – Web Method:

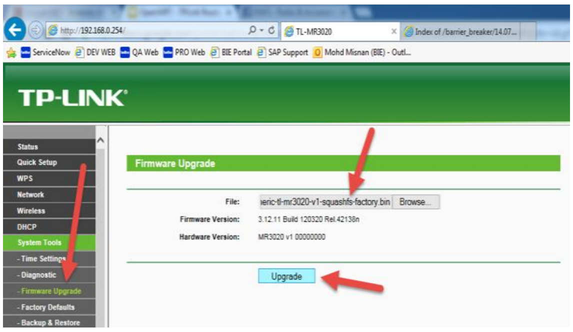


Figure 23 TP-Link web server configuration

Firmware need to be changed to the specified firmware for use the TPlink modem as the APRS IGATE. After done the hardware installation, browse on page 192.168.0.254 on the web browser. Fill up the login and password id with "admin". Next, go to the system Tools Menu, then select the Firmware Upgrade. Browse and find the downloaded factory. bin firmware in the web server browse column and click on OK to upgrade. The firmware flashing process would take 5 minutes time and advised to not disturb the process. The modem will auto-reboot at the end of the process. Open the Putty software as command line is needed to configure the modem. Type telnet to the command line at 192.168.2.2 & get the OpenWRT software banner. Type sysupgrade, to load the most recent firmware : cd/tmp and use wget to download the sysupgrade.bin firmware.

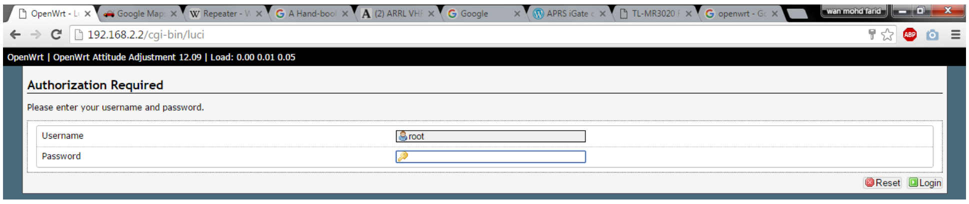
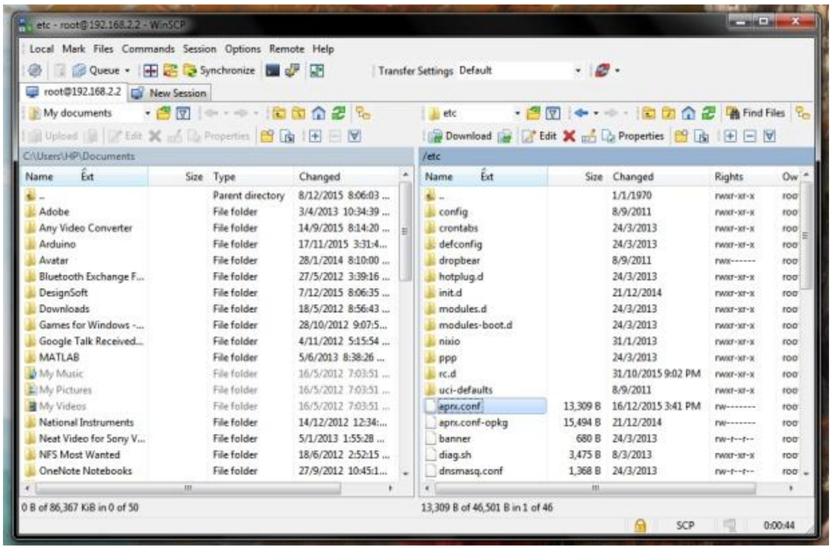


Figure 24 Authentication Web Server

Install APRX:

Open the WinSCP software and set the SCP as the protocol. Insert the 192.168.2.2 as the hostname and 22 as the port number. Key in the username ID and the password. The new firmware should have the aprx module ready installed. Open the file etc/aprx.conf and edit the program line. Fill in the callsign replace the parameter "mycall" in the program. Fill in the server program line with the appropriate APRS-IS server line, for instances , GPS altitude location callsign passcode, comment and the status.



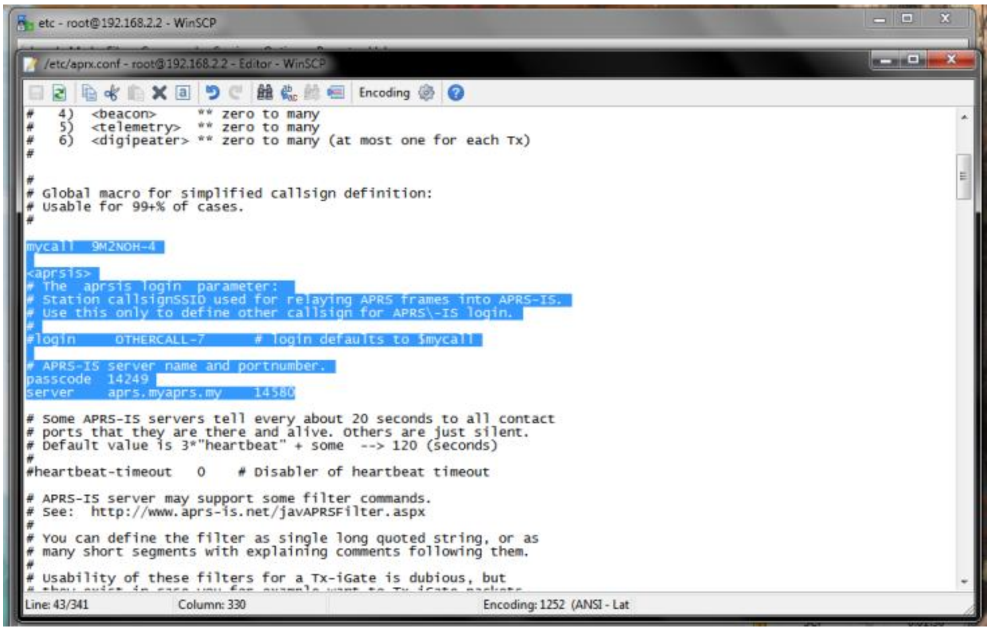


Figure 25 WinSCP configuration for APRX

Connect modem to internet:

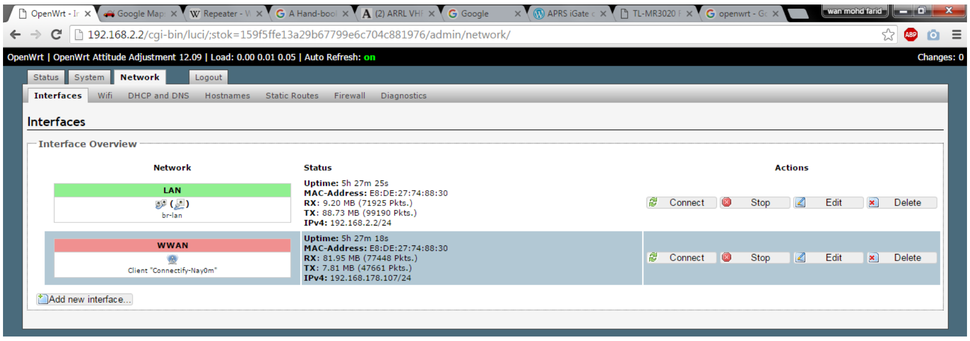


Figure 26 Connect modem to internet connection

Monitor using aprs.fi website:

Figure 27 Monitor I-Gate using aprs.fi

4.1.3 Set Up Water Level Monitoring System

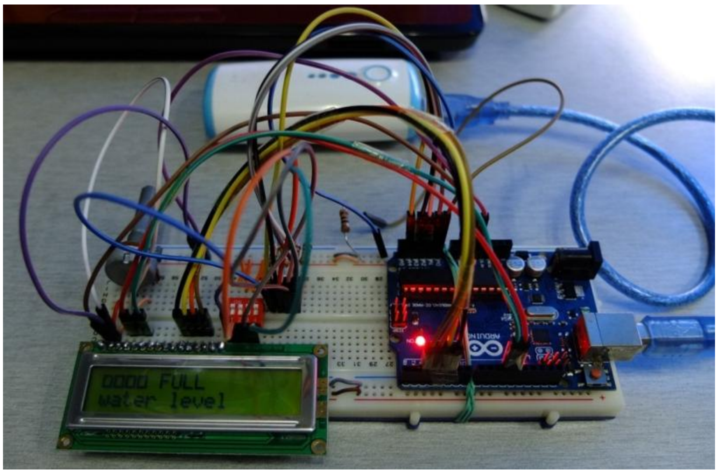


Figure 28 Replace the water level sensor with binary switch for testing purpose.

Level\bit				
Very low	0	0	0	0
Low	1	0	0	0
Moderate	1	1	0	0
High	1	1	1	0
Very high	1	1	1	1

Table 5 Water level binary data

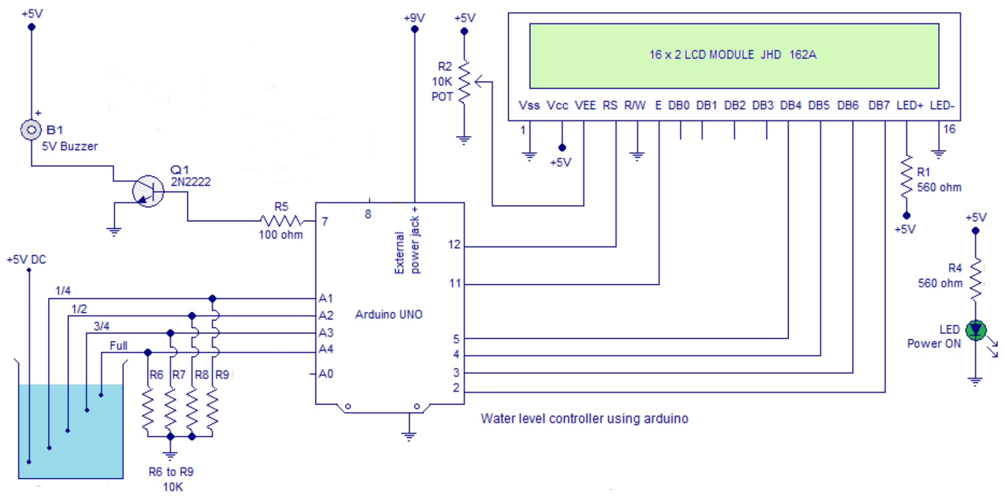


Figure 29 Water Level monitoring schematic

Water level conductance probe can be design based on the water's physical characteristic of weak electrical conductivity. In fact the water level probe was made up of a metal pin and a wire. One end of the wire was tied with the GND of the main circuit board; the other end was submerged into the water.

For the test purpose, binary switch has been used to act as conductance probe. The functional process will be the same as the probe. When the switch is on, the resistance reading will be increased. Hence 4 bit switch can be used to generate different level of resistance which will show the level of water itself. From the picture, LCD screen used to monitor the level of water when binary switch is turning on in ascending order.

From the schematic circuit design, the metal pin was a stainless needle which was fixed on the sliding rule of the optical scale via a measuring rod to form a probe assembly. When the probe (stainless needle) touched the water surface, the resistance between the probe (stainless needle) and the GND (wire) was between a few hundred KΩ to few MΩ; when the probe separated from the water surface, the resistance between the probe and GND was open. Therefore the water surface could be detected according to the value of the resistance.

4.2 Result & Data

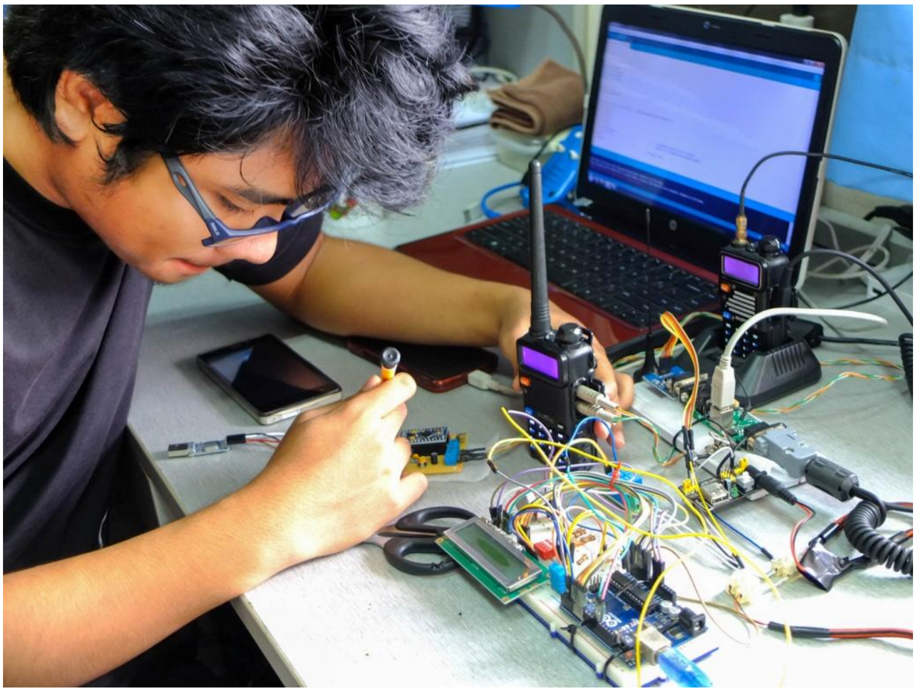


Figure 30 Testing all device before set up the station at the field

Figure 31 Selected Catchment Area

Figure 32 Set up the prototype at the river side

Time	WATER LEVEL	HUMIDITY-percent	TEMPERATURE	GPS location
23:07:16	VERY LOW	61	32	4°22.97' N 100°58.07' E
23:07:17	VERY LOW	61	32	4°22.97' N 100°58.07' E
23:07:18	VERY LOW	62	32	4°22.97' N 100°58.07' E
23:07:19	VERY LOW	62	32	4°22.97' N 100°58.07' E
23:07:20	VERY LOW	61	32	4°22.97' N 100°58.07' E
23:07:21	VERY LOW	61	32	4°22.97' N 100°58.07' E
23:07:23	VERY LOW	62	32	4°22.97' N 100°58.07' E
23:07:24	VERY LOW	62	32	4°22.97' N 100°58.07' E
23:07:25	VERY LOW	62	32	4°22.97' N 100°58.07' E
23:07:26	LOW	62	32	4°22.97' N 100°58.07' E
23:07:27	LOW	62	32	4°22.97' N 100°58.07' E
23:07:28	LOW	62	32	4°22.97' N 100°58.07' E
23:07:29	LOW	61	32	4°22.97' N 100°58.07' E
23:07:30	LOW	61	32	4°22.97' N 100°58.07' E
23:07:32	LOW	62	32	4°22.97' N 100°58.07' E
23:07:33	LOW	62	32	4°22.97' N 100°58.07' E
23:07:34	MODERATE	62	32	4°22.97' N 100°58.07' E
23:07:35	MODERATE	62	32	4°22.97' N 100°58.07' E
23:07:36	MODERATE	62	32	4°22.97' N 100°58.07' E
23:07:37	MODERATE	62	32	4°22.97' N 100°58.07' E
23:07:39	MODERATE	61	32	4°22.97' N 100°58.07' E
23:07:40	MODERATE	61	32	4°22.97' N 100°58.07' E
23:07:41	MODERATE	61	32	4°22.97' N 100°58.07' E
23:07:42	MODERATE	61	32	4°22.97' N 100°58.07' E
23:07:43	HIGH	62	32	4°22.97' N 100°58.07' E
23:07:44	HIGH	62	32	4°22.97' N 100°58.07' E
23:07:46	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:47	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:48	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:49	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:50	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:51	HIGH	61	32	4°22.97' N 100°58.07' E
23:07:52	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:54	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:55	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:56	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:57	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:58	VERY HIGH	61	32	4°22.97' N 100°58.07' E
23:07:59	VERY HIGH	61	32	4°22.97' N 100°58.07' E

Table 6 Field data

The prototype has been tested at the catchment area and showing the good result. The data has been extract by using PLX-DAQ data acquisition software. The water level sensor is running very well and the humidity and temperature sensor also provide the correct data. Data is recorded for every 1 second. The prototype is ready to be tested on the field for ensuring the prototype can detect flood well and analysing how the prototype sustain the surrounding condition. For the next activity, the maximum distance of the transmission data that prototype can handle will be recorded and plotted.

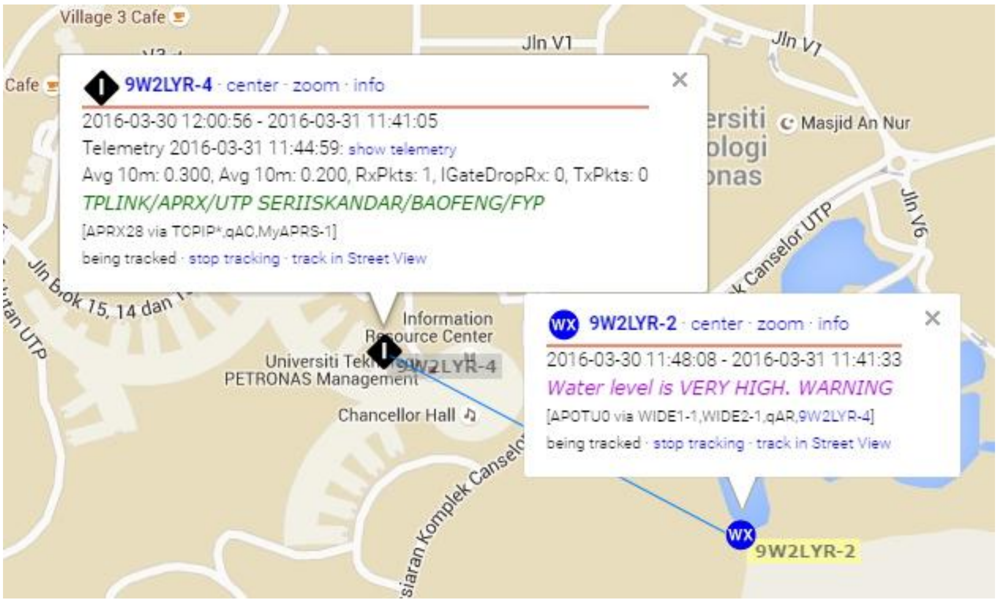


Figure 33 Monitor the warning status at APRS.FI using internet browser

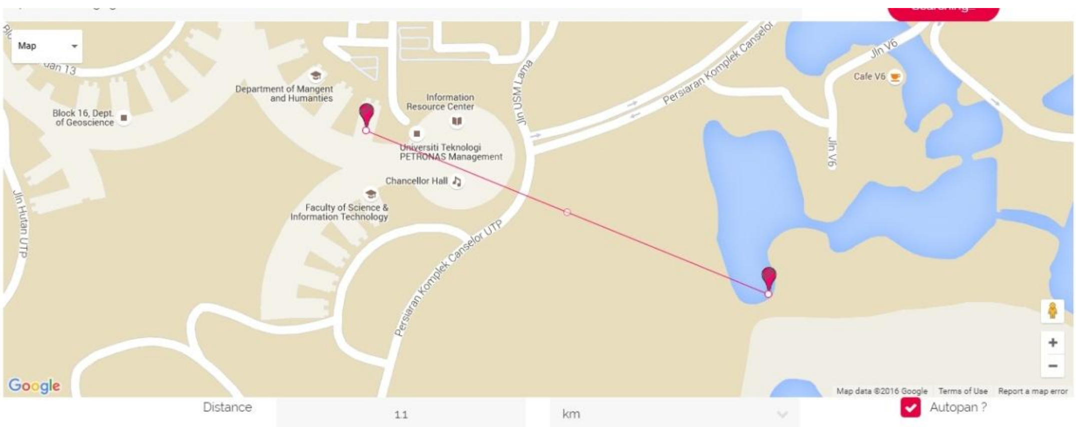
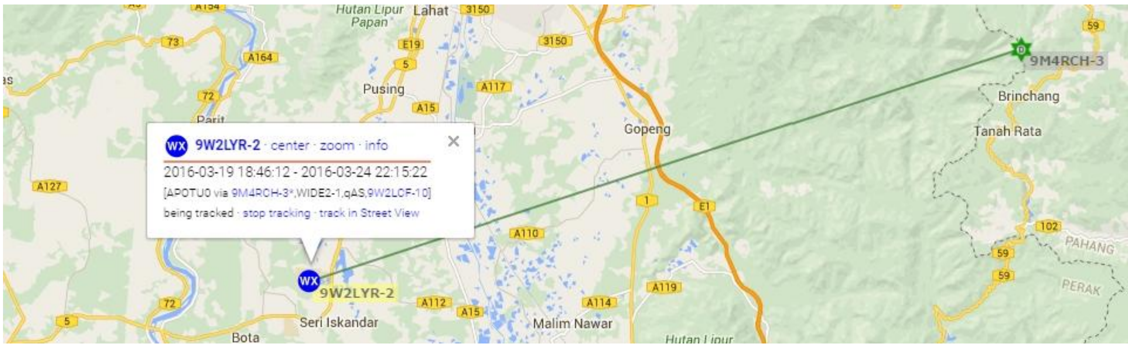


Figure 34 The transmission distance is about 1km



The field station can be heard by the MyAPRS MARTS VHF Digipeater Cameron Highlands which is located about 50km distance.

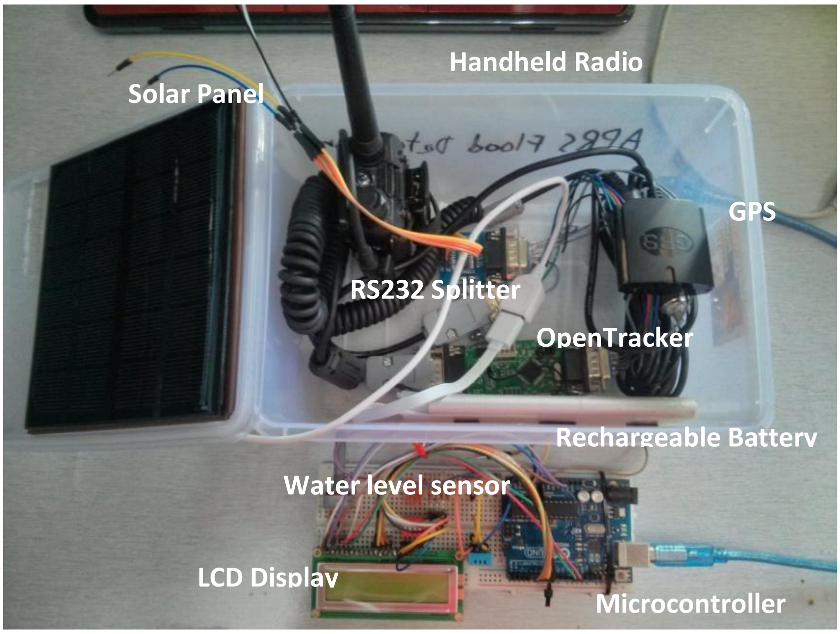


Figure 35 APRS Flood monitoring Prototype

From the figure above, the rechargeable battery 5000mAH capacity is used to power up the arduino and opentracker. Solar panel is used to charge the battery during the day time with the maximum rating of 6V 0.5A. The RS232 cable is modified from single input cable to two input cable which label as port A and port B. Port A (4800 baud) is use to send a GPS location data to opentracker and port B (9600 baud) is used to send water level, humidity and temperature data. Then, the opentracker will encode data received into packet tones APRS format (AX.25 protocol) by audio frequency shift keying (AFSK). Then APRS data will be transmitted using 2 meter VHF handheld transceiver via APRS channel 144.390Hz.

The data will be received by another nearby APRS station for instance I-Gate station and digipeater/repeater station. In this project also, the I-Gate has been set up to receive the flood monitoring station data. The I-Gate is equipped with modem router which integrated with opentracker, VHF handheld transceiver and laptop. When the transceiver received the APRS data, opentracker will decoded the data back from the packet tones to the internet APRS web based. From here, all the telemetry data can be monitored.

Figure 36 Water Level Probe sensor

Figure 37 Heard and decode packet data transmit from field station

USB DVB dongle is normally used to stream DVB-T TV broadcast on computer. This device is based on REALTEK RTL2832U which can be used as a cheap SDR , since the board allows transferring the raw I/Q samples to the host which is ordinarily used for DAB/DAB+/FM demodulation. It can be converted into software defined radio SDR device by flashing the new firmware and library to used as SDR. This device can be control using SDRsharp software. From here we need to configure the APRS frequency channel, the offset tuning, RF gain, audio noise reduction, bandwidth, squelch and IF filter. When the SDR can heard APRS packet data, the signal can be decoded by using AFSK 1200 decoder which use sound modem card in the computer to decoded the signal.

The AX.25 Frame All APRS transmissions use AX.25 UI-frames, with 9 fields of data:

	AX.25 UI-FRAME FORMAT								
	Flag	*Destination Address*	*Source Address*	*Digipeater Addresses (0-8)*	*Control Field (UI)*	*Protocol ID*	*INFORMATION FIELD*	*FCS*	*Flag*
Bytes:	1	7	7	0–56	1	1	1–256	2	1

Figure 38 AX.25 protocol

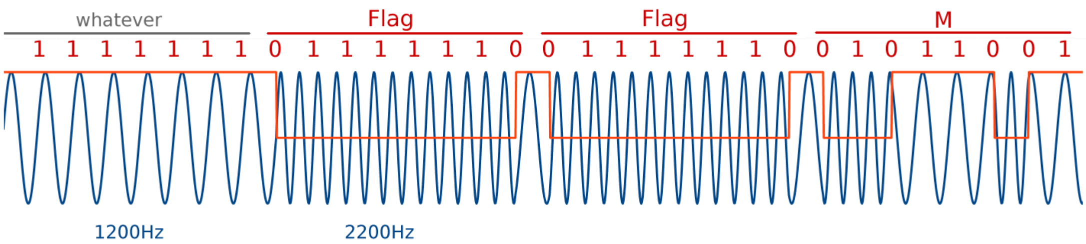


Figure 39 Example of first few bits on APRS Packet

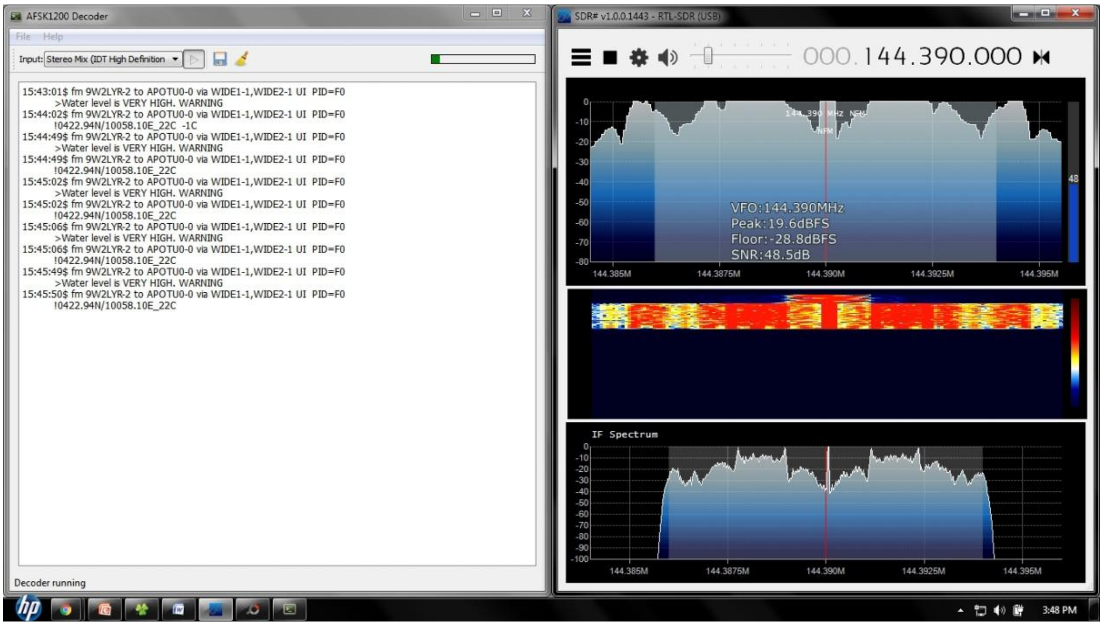


Figure 40 Packet data is heard and decoded by AFSK 1200 decoder

AFSK 1200 Decoder showing the packet data heard by the RTL-SDR USB dongle. The packet data contain the sender's and recipient's callsign, GPS location, temperature reading and also the water level warning status.

Figure 41 Raw Packet Data from the aprs.fi web server

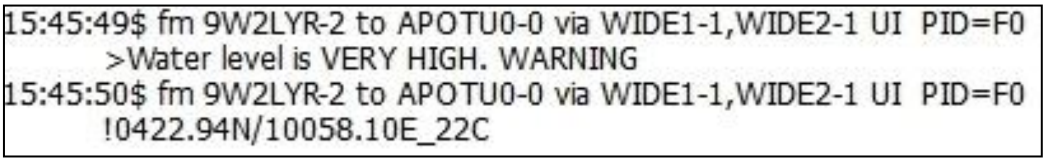


Figure 42 Packet data decoded by the AFSK1200 DECODER

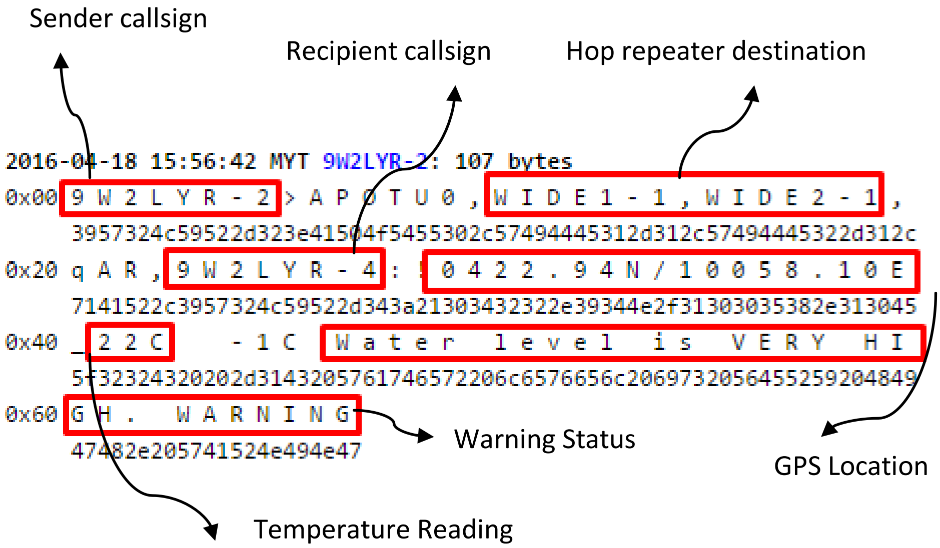


Figure 43 Hex code of packet data

Hexadecimal data	Text data
3957324c59522d323e41504f5455302c57494445312d312c57494445322d312c	9W2LYR-2>APOTU0,WIDE1-1,WIDE2-1,
7141522c3957324c59522d343a21303432322e39344e2f31303035382e313045	qAR,9W2LYR-4:!0422.94N/10058.10E
5f32324320576174657220 6c6576656c20697320564552592048494748 2e205741524e494e47	_22C Water level is VERY HIGH. WARNING

Table 7 Convert Hex data to text

Packet is received as 4 frames of data (0x00, 0x20, 0x40, 0x60) which consist of the callsign of recipient and sender, hop repeater destination, GPS location, temperature reading and the water level warning status.

Chapter 5: CONCLUSION & RECOMMENDATION

Flood monitoring old system.

Flood monitoring new system

In Malaysia, flood disaster is responsible for the loss of precious lives and destruction of large amounts of property. A lot of effort and control are required to be put in developing systems which help to minimize the damage through quick information broadcasting. A complete real-time flood monitoring system has been designed and Implemented in this paper which uses wireless sensor network to monitor water conditions: water level. The developed monitoring system presents useful characteristics as large network capacity, sensor hardware compatibility, long-range communication, and minor impact on the natural environment.

The software and the hardware are researched and developed independently. They can not only tremendously ensure a stable, expansible and reliable system, but also reduce the cost expenses.

Flood monitoring using Amateur Packet Radio System on VHF, provides low power serial formatted data packet frames AX.25 radio transmission and equipped with reliable touch/conductance sensor and infrared sensor. This complete system will do self-monitoring for adjusting measurement action for utilization arrangement and to capture events of interest. The water level and amount of precipitation could be monitored to provide real-time feedback for advanced warning system and prediction.

For FYP1, APRS field station, main station and basic water level monitoring system has been set up. For FYP 2 the integration and interfacing for each subsystem to a complete system is been set up. Water level monitoring system is combined with APRS field station.

Based on the result of the project, the flood monitoring system is succeed to be implemented and is working fine. The modified water level probe is very reliable to monitor the water level and the flood warning packet data is succeed to be transmitted to monitoring station in 1km distance. Furthermore, field station can transmitted the packet data to the Cameron highland digipeater in around 50km distance. Thus, it show that this project is very useful to give a early warning to a local authorities and resident to prepare and evacuate which will give an advance in term of time and money and also can prevent from the death and losses due to early preparation.

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APPENDICES

Appendix 1

```
#include "DHT.h"
#define DHTPIN 3
#define DHTTYPE DHT11 // DHT 11
#include <LiquidCrystal.h>
int sump=A0;
int qut=A1;
int hlf=A2;
int thf=A3;
int ful=A4;
int s;
int q;
int h;
int t;
int f;
int v=100; //comparison variable(needs some adjustment)
int counter = 1;
LiquidCrystal lcd(12, 11, 7, 6, 5, 4);
DHT dht(DHTPIN, DHTTYPE);
int d=2;


void setup()
{
pinMode(qut,INPUT);
pinMode(hlf,INPUT);
pinMode(qut,INPUT);
pinMode(ful,INPUT);
pinMode(sump,INPUT);
lcd.begin(16, 2);
dht.begin();
Serial.begin(4800);                    //OPEN SERIAL LINE AT 4800
pinMode(2,INPUT);
pinMode(A5,OUTPUT);
}


void loop ()
{
q=analogRead(qut);
h=analogRead(hlf);
t=analogRead(thf);
f=analogRead(ful);
float y = dht.readHumidity();
float r = dht.readTemperature();
d=digitalRead(2);
y=y+10;

if (isnan(t) || isnan(h))
  {
    Serial.println("Failed to read from DHT");
  }
  else
  {

    lcd.setCursor(0,2);
    lcd.print("H:");
    lcd.print(y);
    lcd.print("%");
    lcd.print("T:");
```

```
    lcd.print(r);
    lcd.println("C");

    //Serial.print("HUMID: ");
   //Serial.print(y);
    //Serial.print(" %");
   // Serial.print("TEMP: ");
    //Serial.print(r);
    //Serial.println(" *C");
    //delay(500);



  }

if(f>v && t>v && h>v && q>v || d==0 )
{
lcd.setCursor(0,0);
lcd.print(char(219));
lcd.print(char(219));
lcd.print(char(219));
lcd.print(char(219));
lcd.setCursor(5,0);
lcd.print("VERY HIGH");
digitalWrite(A5,LOW);

Serial.print("!>0422.97N/10058.07E");
Serial.print("_5");
Serial.print(",");
Serial.print(y);
Serial.print(",");
Serial.print(r);
Serial.print("#");
Serial.print(d);
//Serial.print(counter);                                    //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                      //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                               //30,000ms = 30sec

}
else
{


if(f>v && t>v && h>v && q>v && d==0 )
{
lcd.setCursor(0,0);
lcd.print(char(219));
lcd.print(char(219));
lcd.print(char(219));
lcd.print(char(219));
lcd.setCursor(5,0);
lcd.print("VERY HIGH");
digitalWrite(A5,LOW);

Serial.print("!>0422.97N/10058.07E");
Serial.print("_5");
Serial.print(",");
Serial.print(y);
```

```
Serial.print(",");
Serial.print(r);
Serial.print("#");
Serial.print(d);
//Serial.print(counter);                              //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                        //30,000ms = 30sec

}
else
{

if(f<v && t>v && h>v && q>v || d==0 )
{
lcd.setCursor(0,0);
lcd.print(char(219));
lcd.print(char(219));
lcd.print(char(219));
lcd.print("_");
lcd.setCursor(5,0);
lcd.print("HIGH      ");
digitalWrite(A5,HIGH);


Serial.print("!>0422.97N/10058.07E");     //BEGIN MESSAGE BUT DON'T SEND
YET...
Serial.print("_4");
Serial.print(",");
Serial.print(y);
Serial.print(",");
Serial.print(r);
Serial.print("#");
//Serial.print(counter);                              //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                        //30,000ms = 30sec

}
else
{
if(f<v && t<v && h>v && q>v  || d==0 )
{
lcd.setCursor(0,0);
lcd.print(char(219));
lcd.print(char(219));
lcd.print("_");
lcd.print("_");
lcd.setCursor(5,0);
lcd.print("MODERATE ");
digitalWrite(A5,HIGH);

Serial.print("!>0422.97N/10058.07E");     //BEGIN MESSAGE BUT DON'T SEND
YET...
Serial.print("_3");
Serial.print(",");
Serial.print(y);
```

Appendix 1 continue...

```
Serial.print(",");
Serial.print(r);
Serial.print("#");
//Serial.print(counter);                                    //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                      //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                               //30,000ms = 30sec

}
else
if(f<v && t<v && h<v && q>v  || d==0 )
{
lcd.setCursor(0,0);
lcd.print(char(219));
lcd.print("_");
lcd.print("_");
lcd.print("_");
lcd.setCursor(5,0);
lcd.print("LOW       ");
digitalWrite(A5,HIGH);

Serial.print("!>0422.97N/10058.07E");     //BEGIN MESSAGE BUT DON'T SEND
YET...
Serial.print("_2");
Serial.print(",");
Serial.print(y);
Serial.print(",");
Serial.print(r);
Serial.print("#");
//Serial.print(counter);                                    //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                      //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                               //30,000ms = 30sec

}
else
{
if(f<v && t<v && h<v && q<v  || d==0 )
{
lcd.setCursor(0,0);
lcd.print("_");
lcd.print("_");
lcd.print("_");
lcd.print("_");
lcd.setCursor(5,0);
lcd.print("VERY LOW ");
//Serial.println("WATER LEVEL IS VERY LOW");
//Serial.print("DATA,TIME,");
digitalWrite(A5,HIGH);

//Serial.print("1");
//Serial.print(",");
//Serial.print(y);
//Serial.print(",");
//Serial.println(r);
//delay(1000);
```

Appendix 1 continue...

```
Serial.print("!>0422.97N/10058.07E");     //BEGIN MESSAGE BUT DON'T SEND
YET...
Serial.print("_1");
Serial.print(",");
Serial.print(y);
Serial.print(",");
Serial.print(r);
Serial.print("#");
//Serial.print(counter);                                        //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                          //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                            //30,000ms = 30sec

}
else

{
lcd.setCursor(0,0);
lcd.print(" ");
lcd.print(" ");
lcd.print(" ");
lcd.print(" ");
lcd.setCursor(5,0);
lcd.print("ERROR!            ");
digitalWrite(A5,HIGH);

Serial.print("!>0422.97N/10058.07E");     //BEGIN MESSAGE BUT DON'T SEND
YET...
Serial.print("_E");
Serial.print(",");
Serial.print(y);
Serial.print(",");
Serial.print(r);
Serial.print("#");
//Serial.print(counter);                                        //  ...CONCATEN
ATE VALUE OF count TO OUTPUT...
Serial.print("\r\n");                                          //    ...SEND
CR/LF TO COMPLETE AND TRANSMIT PACKET.
counter++;
delay(3000);                                                  //30,000ms = 30sec

}

}}}


}
}
```

```
#if 1
__asm volatile ("nop");
#endif

#ifndef _CONFIGURATION_INCLUDED
#define _CONFIGURATION_INCLUDED
#include "config.h"
#endif

// GPS libraries
// Choose between GPS and BD
//#include <TinyGPS++BD.h>
#include <TinyGPS++.h>
TinyGPSPlus gps;
// The packet decoding libs
#include <MicroAPRS.h>

MicroAPRS microaprs = MicroAPRS(&Serial);
// APRS Buffers
#define BUFLEN (260) //original 260
char packet[BUFLEN];
int buflen = 0;
bool showmsg, showstation;



float latitude = 0.0;
float longitude = 0.0;
float wayPointLatitude, wayPointLongitude;
float latitudeRadians, wayPointLatitudeRadians, longitudeRadians,
wayPointLongitudeRadians;
float distanceToWaypoint, bearing, deltaLatitudeRadians,
deltaLongitudeRadians;
const float pi = 3.14159265;
const int radiusOfEarth = 6371; // in km

// Turn on/off debug, on by default on pin 2,3
#undef DEBUG


// Varables for Packet Decode
const unsigned int MAX_INPUT = 103;
static unsigned int packetDecoded = 0;

char *lastCall="";
String rxCallsign="";
unsigned int rxStation;

unsigned int mCounter = 0;
unsigned int txCounter = 0;
unsigned long txTimer = 0;
#ifdef I2C16X2
bool packetDisplay = 0;
unsigned long displayTime = 0;
#endif
unsigned long lastTx = 0;
unsigned long lastRx = 0;
unsigned long txInterval = 80000L;  // Initial 80 secs internal

int lastCourse = 0;
byte lastSpeed = 0;
```

Appendix 1 continue...

```
byte buttonPressed = 0;

// Unused
//static unsigned int Hd,Ti,Di,Bn = 0;

int previousHeading, currentHeading = 0;
// Initial lat/lng pos, change to your base station coordnates
float lastTxLat = HOME_LAT;
float lastTxLng = HOME_LON;
float lastTxdistance, homeDistance, base = 0.0;

// Used in the future for sending messages, commands to the tracker
const unsigned int MAX_DEBUG_INPUT = 30;
```