



Research Project Report

Designing and Implementation Exploration Vehicle Remote Controller Using APRS. Protocol



By

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ABSTRACT

This thesis is about the study and design embedded systems that can establish long range communication network between control station and Exploratory vehicle where located far more than conventional wireless network can be reached, All the Control or Navigate data whatever be converted to readable as a number or letter to send to the Transceiver using a protocol APRS (Automatic Position Report System) or another name called AX.25 by conversion of AFSK (Audio Frequency Shift Keying), or digital audio input through the Carrier as Radio Frequency through antennas emit radio waves in the VHF Band by designing embedded systems using microcontrollers of small and programming,

The main objective is to send data from very far distant over the air to distant areas without communication networks. For example, from deep in forest to transport data to a reception area where data can be fed into the network, or transmitted from Earth stations via the atmosphere to the satellite or to other selected stars. The transmission protocol that is used to design the system for remote communication. The advantages of such devices is small size of the device makes it possible to assemble and use it to transfer data. Low power consumption and very small integrate in small robot or exploration vehicle by designing this Embedded device, compare to which already has a large and expensive instruments. The result is that the device is capable of receiving, receiving, and converting data at data speeds of 1200 bps transmitting 300 mW at 2 km and 5 W at 10 km respectively. Delivered to meet the needs of remote data transmission through the air (Free Space) effectively.

Keywords: APRS, Packet Radio, AX-25, Exploration Vehicle

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This research report is well done. With great care from Research Advisor Assoc.Prof.Dr.Somsak Mithata Research Advisor Which has advised. Guiding guide Accuracy adds important issues and encouragement from start to finish, guiding the accuracy of the research report, which is very useful for this research. Researchers are very grateful for this opportunity.

Thank you staff of Department of Business Computer. All business executives are encouraged to collect information in this research and provide advice, encouragement, and support in their research, including authors of texts, papers, and research articles. References in this research include: Thank you to all of you who have encouraged and assisted the researcher in all aspects of the project. This was a great success.

However, the value and benefits of this research will be extended to all parents, relatives, teachers, teachers and all of you.

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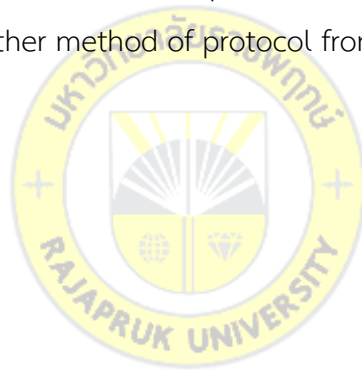
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Chapter 1

Introduction

1.1 Background and Problem

At present day, Vehicle in the survey or Exploration are very necessary in remote areas or dangerous areas, as well as control of Exploration Vehicle in space. This is a far more distant way of communicating with the existing Technology that exist today, such as Wireless communication over the Internet or via cellular phone communication systems, or even the Digital Radio-Controlled systems *have limitation of communication range* and this is the problem which lead to be researched

In this paper, we will use the APRS Protocol, which has the ability to transmit and receive data remotely and with high accuracy. The Protocol Automatic Packet Reporting System (APRSTM) is based on the Protocol It is capable of providing fast, reliable communication between multiple nodes, which can exchange location information in real time and with high accuracy. Remote transmission of data depends on the transmission of data transmitted by AFSK Modulation {Audio Frequency Shift Keying) transmitted and received through Radio Frequency waves. The communication range is based on RF propagation. The basic idea of the software is that each station with new data sends a position update to all participating nodes. Upon receipt, the information is displayed as an update on the Electronic Map or Google Map. The APRS reference system uses one-to-many protocols to update participating nodes with standard data formats, such as Mic-E, which have been developed to optimize data transmission. System users can modify these standard formats by constantly detecting local or remote traffic regardless of the hardware or software used. This is why conventional communication applications cannot be achieved by radio frequency control.

The Automatic Packet Reporting System (APRSTM) was developed in the early 1990s by Bob Bruninga, a contractor at the U.S. Naval Academy in Annapolis,

Maryland, to support tracking of U. S. Naval Academy GPS-equipped boats in local waterways.

APRS protocol was created for use in building a Wireless local area network in the early 1990s, it was widely used and widely accepted by Amateur radio operators around the world. The creation of a relay system called the Digipeaters (simplex repeater) was created to relay positional data in addition and also the custom information embedded to radio signals from the origin of the output to the Receiving station will send the data through an interface of Internet Gateway that connects pass data to the Internet network. This enables APRS network coverage to expand globally. By having less bandwidth, making it less costly, using less information bandwidth on the Internet. This results in multiple point-to-point or point-to-point data exchanges between nodes separated by thousands of miles. Currently, two APRS users located anywhere in the world with Internet navigation can exchange location information and other information in this system without any distances. This principle will be developed and used in this research to prove the concept and application of remote communication as well as the development of embedded system with Unmanned Exploration Vehicle

APRS has a low maximum channel throughput with a resulting increase in network delay. The low measure of throughput introduces an additional time that a packet needs to wait in order to be successfully transmitted. APRS provides no indication or guarantee of packet delivery, resulting in decreased reliability. In order to improve the key performance indicators, the APRS protocol aspects governing the characteristics will need to be addressed. (Van Tonder, H. P: 2005)

Tucson Amateur Packet Radio (TAPR), which is an educational research and development organization, manages the development of the APRS implementation. Their research addresses the maintenance of APRS with regard to routing issues that presently result in network performance degradation. Research seems to indicate that there is no ongoing development of APRS other than that of TAPR [24]

1.4 Research Hypothesis

1.4.1 Establish long distance network for Exploration Vehicle with APRS protocol

1.4.2 Designing small embedded system with microcontroller to handle the communication instead of using the big old Radio Modem

1.4.3 Create the custom command which use for remote Control the Exploration Vehicle in the remote distance

1.5 Research Benefits

1.5.1 To prove, demonstrate and create the communication system by using APRS protocol can help to solve the problem the limitation of long distance communication

1.5.2 It would be possible to implement this system to any kind of communication in the rural area where no infrastructure of wireless communication networks.

1.6 Research Scope

This research scope will focus to design and implementation the communication system that use APRS protocol by designing with small Microcontroller along with other components that used for controller the vehicle. At the result of this research will be able to demonstrate the complete remote control system which consist of the base station and Vehicle station.

To support these objectives, an APRS network was developed to provide:

1.6.1 A self-organized multi-node communications system that was then integrated to support the rapid, reliable exchange of information for local- and wide-area tactical, real-time events on radio and Internet networks.

1.6.2 The ability to monitor and track friendly assets and to forward positional data to remote commands.

1.6.3 A mapping engine capable of interpreting the received data overlay on Google Map.

1.6.4 Operations in environments where the Internet is not available.

1.7 Definitions

1.7.1 **Automatic Packet Report System (APRS)** was developed in 1992 by Bob Bruninga. APRS is a digital communications protocol for exchanging information among a large number of stations covering a large (local) area, APRS operates entirely in an unconnected broadcast fashion, using unnumbered AX.25 frames.

1.7.2 **AFSK** (*Audio frequency-shift keying*) is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone. Normally, the transmitted audio alternates between two tones: one, the "mark", represents a binary one; the other, the "space", represents a binary zero. AFSK differs from regular frequency-shift keying in performing the modulation at baseband frequencies. In radio applications, the AFSK-modulated signal normally is being used to modulate an RF carrier (using a conventional technique, such as AM or FM) for transmission.

1.7.3 **Embedded system** is a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is *embedded* as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today. Ninety-eight percent of all microprocessors are manufactured as components of embedded systems. Examples of properties of typically embedded computers when compared with general-purpose counterparts are low power consumption, small size, rugged operating ranges, and low per-unit cost. This comes at the price of limited processing resources, which make them significantly more difficult to program.

1.7.4 **Microcontroller (MCU for MicroController unit)** is a small computer on a single integrated circuit. In modern terminology, it is a System on a chip or SoC. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of electric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in

contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.

1.7.5 **Exploration vehicle** designed to move across the surface of a planet or other celestial body. Some vehicle have been designed to transport members of a human spaceflight crew; others have been partially or fully autonomous robots. Vehicle usually arrive at the planetary surface on a lander-style spacecraft.^[1] Rovers are created to land on another planet, besides Earth, to find out information and to take samples. They can collect dust, rocks, and even take pictures.

1.8 Research Structure

- **Chapter 1 Introduction** explains the background and importance of the problem. The basic principles of APRS, the protocol, the problem of application of data communications, the presentation of APRS protocols, goals, research objectives, scope of work and expected results from the research.
- **Chapter 2 Literature review** describes research related to theses. In various protocols the basic system for comparing the present and explain the complexities and constraints of networking.
- **Chapter 3 Research Methodology** involved. It consists of the basic requirements of the system required in the design. Including how the protocols worked and applications are implemented by using this protocol.
- **Chapter 4 Design Approach** after the design and installation on the experimental equipment that was designed to be experimental and to compare the performance of the distance of the system. Presented to the device for maximum efficiency between theoretical and field trials.
- **Chapter 5 Result and Conclusion of Experimental Results and Comparison of Research and Experimental Results and Guidelines for Future Research and Development.**

Chapter 2

Literature review

2.1 Problems in Data Communication Applications

By the problem of distance transmission. The complexity and size of the device comes as a why choose APRS protocol? The answer is because APRS is very easy to communicate in terms of remote data transmission capabilities. Rapidly deploying infrastructure does not require any setup, which is different from wireless internet or WIFI, which is complicated to install and has a limited distance of only 100 feet or 30 meters. Or must be in the service area of the telephone network. However, the adoption of the APRS protocol can extend the communication range by more than 2-10 kilometers, depending on the transmission variable, which is a line of sight. And the height of the receiving and sending stations. It determines the distance to communicate. Figure 2.1 shown a comparison of constraints and advantages in using APRS.

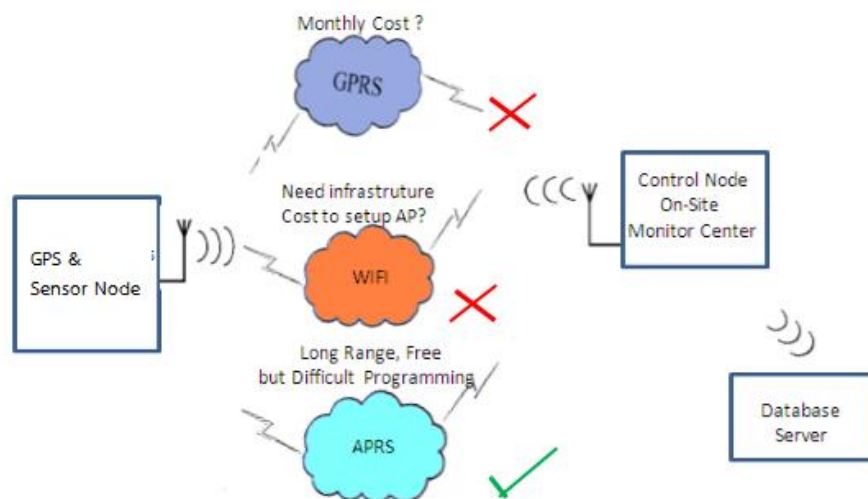


Fig 2.1 Comparison the option for purposed Wireless communication

APRS is a protocol designed to meet the need to compensate for the two networks with price and size problems, as well as system setup. Infrastructure by the APRS solution flexibility and sophistication. The flexibility of the network means the

ability to work efficiently. Support of different network. This will include reducing routing, re-routing of networks, and the number of required basics of network infrastructure. Network complexity refers to the network architecture that hosts the hardware and software components, and the metrics. Intelligence network needed for each host.

This research, we are interested to offer the protocol. Data transmission with APRS protocols. The study and design of embedded microcontroller-based embedded devices are designed to be deployed in conjunction with radio frequency communication networks. Since there is currently no development of APRS-based devices that are small in size, but large in size and not suitable for small networks, Figure 2.2 compares the size of the radio modem. Available in the market, which is as large as a notebook or A4 paper size with the device designed to be smaller than the palm and can also be programmed to the measurements from the sensor and coordinates from GPS. As needed



Fig. 2.2 Size and development of APRS device

To understand the concept and Principles of data access and communication. In this order, the transmission of the available information in various formats. The basic system for data communication can be compared with this research. For experiments in the design of equipment development to be qualified and targeted which will be described on each of available Wireless Network.

At present, there are many wireless communications that are used, but communication is both near and far, and the choice is the system that is used and

can communicate wirelessly with the use of distance. It is explained to compare just 4 types.

- Cellular Network
- WiFi
- Radio Frequency (RF)
- APRS Protocol

2.2 Basic Theory of Cellular Network

Brief description to be compared by data in cellular phone communication system. GSM, GPRS, CDMA, GPRS, 2G / GSM, 3G, 4G / LTE, EDGE based on frequency characteristics and data transfer speed. Communicate By normal communication Do it in a format called "M2M" (Machine-to-Machine)

For example, in the use of mobile communication networks, part of the connection is the transmission, use of the radio link, and the other part uses 2 Mbit link / s. PCM transmits the radio between the mobile station and the transmitter. The base and data must be adjusted to carry more than 2 Mbit / s. The remaining PCM transmission of the radio link network is the most fragile part of the connection and Good workmanship is needed to ensure high quality and reliable operation. The GSM 900 and GSM 1800 frequency ranges are listed below.

The interface uses GSM as a digital air interface. The analog voice is converted to a digital air interface. Digital before sending out before. By sending, the communication speed in the GSM RF carrier can reach 270 Kbps with 1 bit at 3.9 usec, as shown in Figure 2.3.

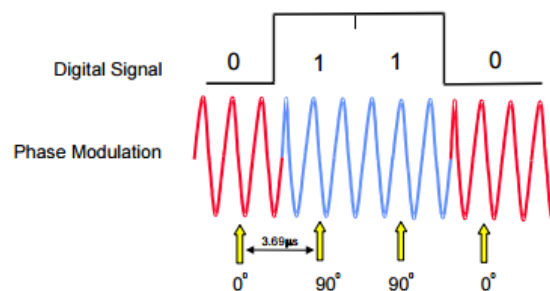


Fig. 2.3 Phase Modulation ของ GSM [1]

Gaussian minimum shift keying (GMSK) Used to convert digital signals. In GMSK, only phase change. By phase, it changes to digital "1" or a "0", occurring during the time period in each phase. Block the system diagrams roughly as shown in the figure to see the complex component [2]

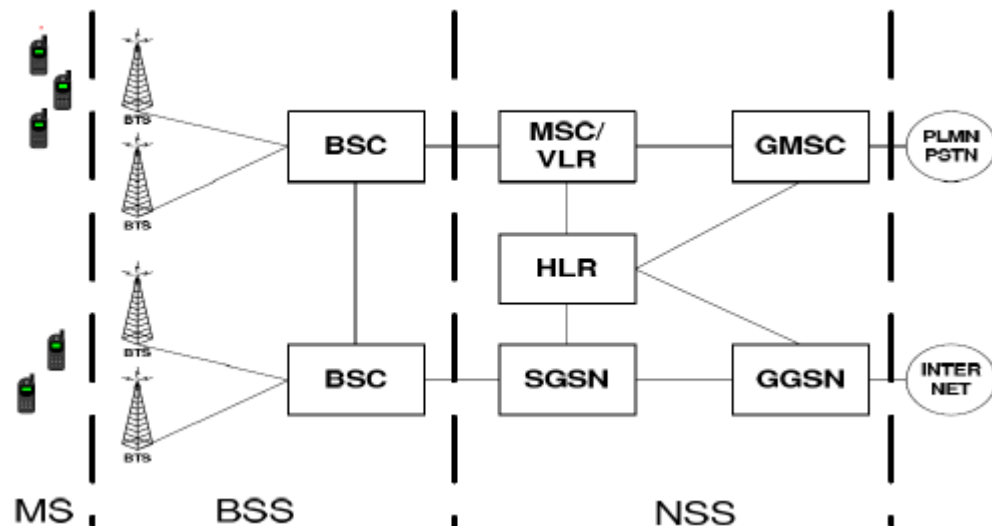


Fig 2.4 Data Flow of Cellular network [2]

Pro:

- Solid Communication Network within the Infrastructure
- Communication between network service provider

Con:

- Communication breakdown without Infrastructure network
- High Cost or Monthly bill
- Consumed more power than other while data communicate occurred

2.3 System Principle of WiFi

Wi-Fi It is a wireless local area network (WLAN) that adopts IEEE 802.11 standard over 2.4 GHz UHF and ISM Band at 5 GHz ISM. Wi-Fi to provide connectivity to devices at a radius of approximately 33 meters or 66 feet. From the point where the Access point is installed. WIFI It is useful for the internet a lot of connections like

connecting. But what is usually connected to the external Cloud. The server is not connected directly to the smartphone. It is also not recommended for battery powered devices due to the high power consumption. The 802.11b standard is divided into 14 frequency bands. The FCC uses 1 to 11 in the US. In Europe, channels 1 to 13 are used. The frequency channel is the center frequency with 5 MHz channel spacing. In each channel, there is a technique for selecting multiple channels simultaneously. The data is called Carrier Sense Multiple Access with Collision Avoidance (CSMA / CA). The WIFI system cannot provide the desired distance. But there is a system called WIMAX that can provide Wireless coverage area more and more using the 802.16 standard that the service provider can install. Public networks (eg, ISP) are the same as cellular systems. Array antennas are installed, with the goal of maximizing coverage. The most popular is the MESH mode. (Citcuittoday, 2008: online)

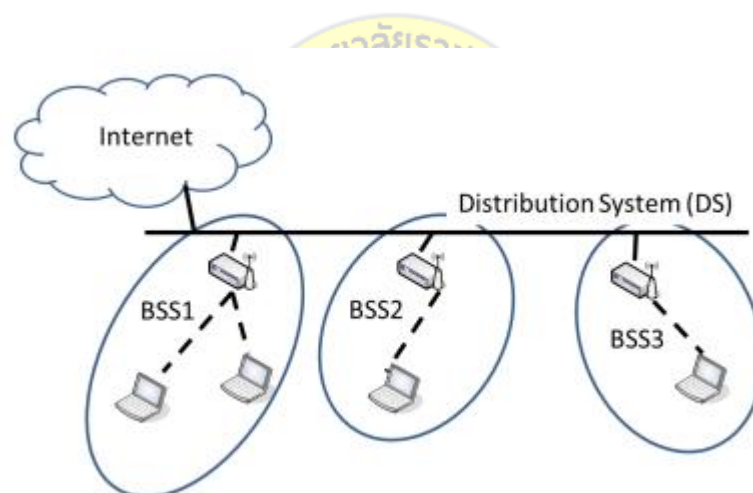


Fig. 2.5 Basic Block Diagram of WiFi 802.11 topology [3]

Currently, IEEE 802.11 WLAN works in 2.4 GHz and 5 GHz. The baseband spectrum is 20 MHz wide, but 802.11n and 802.11ac allow wider channel use by multi-channel bonding together. The number of available 20 MHz channels in the 2.4 GHz and 5 GHz frequency bands are 11-13 and 19-25 respectively, depending on the domain rules. All devices are in the same transmission and sharing or overlapping range. Channels also have channel allocation.

IEEE 802.11 identifies two layers of Open Systems Interconnection (OSI). The format is in the data link and the physical layer, as shown in Figure 2.5. Medium

Access Control (MAC) protocol, which is responsible for signaling control in the physical layer BSS, is responsible for the transmission and transmission of data. Each data packet is passed to each layer and encapsulated by a specific layer. Finally, the corresponding layer in the receiving frame decoder. Frames on each floor are essential for the operation of the floor. But this usage is reduced for network performance.

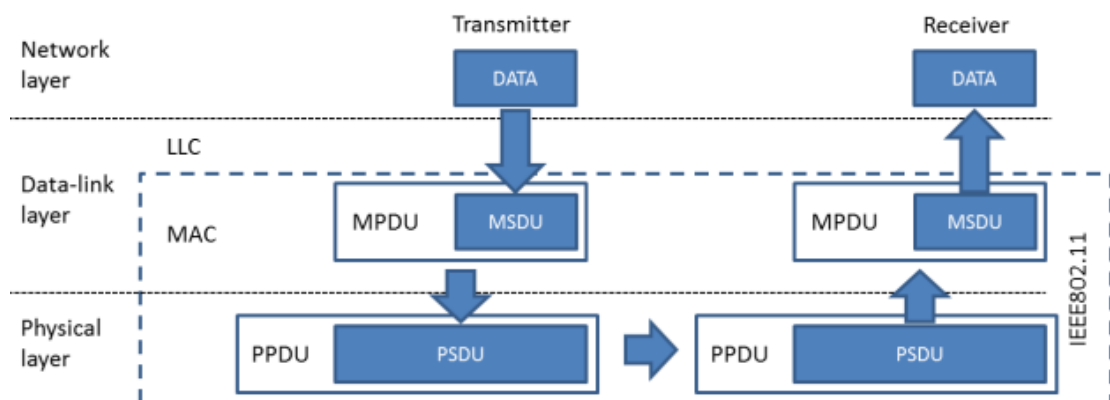


Fig. 2.6 Simple of OSI and Data Frame

WiFi is useful for the internet, a lot of connections like connecting. But what is usually connected to the external Cloud. The server is not connected directly to the smartphone.

The Wifi has a frequency division. The 802.11b standard is divided into 14 frequency bands. The FCC uses 1 to 11 in the US. In Europe, channels 1 to 13 are used. The frequency channel is the center frequency. Carrier Sense Multiple Access with Collision Avoidance (CSMA / CA) is a common method used to send multiple data simultaneously, there are basic steps. [4]

The WIFI system can not provide the desired distance. But there is a system called WIMAX that can provide Wireless coverage area more and more using the 802.16 standard that the service provider can install. Public networks (eg, ISP) are the same as cellular systems. Array antennas are installed with the aim of covering the area as much as possible. The most popular is the MESH mode as shown below.

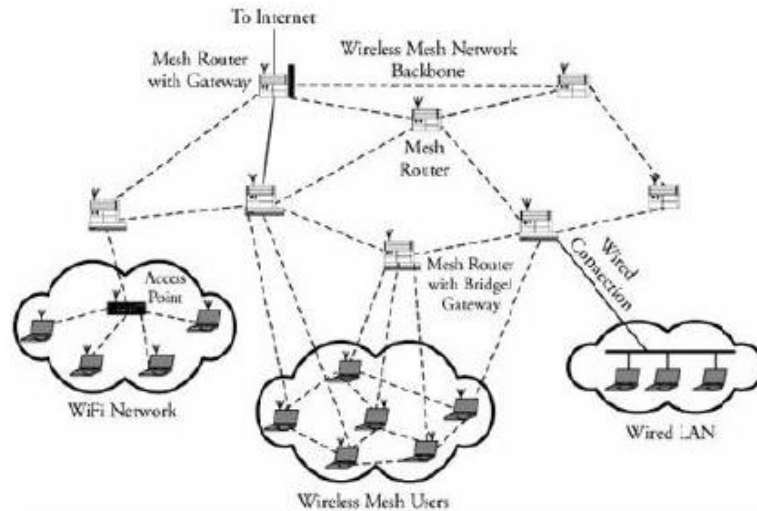


Fig. 2.7 Mesh Network in WIMAX [4]

The cost of the system at each service point is \$ 300USD (15,000baht). Each base must be installed at a starting price of \$ 5,000 to \$ 1,000. The distance from each base can reach as far as 40-50. Km at a speed of 75 Mbps and at each point of service, the initial communication speed at 15Mbps. [4]

Table 2.1 Specification 802.16 standard for 3 types [4]

| | 802.16 | 802.16a | 802.16e |
|---------------------|----------------------|--|--|
| Spectrum | 10-66 GHz | 2-11 GHz | 2-6 GHz |
| Channel bandwidth | 20, 25, and 28 MHz | 1.5 to 20 MHz | 1.5 to 20 MHz with UL sub channels |
| Modulation | QPSK, 16QAM, 64 QAM | OFDM 256 sub carriers QPSK, 16QAM, 64 QAM | OFDM 256 sub carriers QPSK, 16QAM, 64 QAM |
| Bit rate | 32-134 Mbps (28 MHz) | 75 Mbps (20 MHz) | 15 Mbps (5 MHz) |
| Channel conditions | LOS | Non-LOS | Non-LOS |
| Typical cell radius | 2-5 Km | 7-10 Km, max 50 Km | 2-5 Km |
| Application | Fixed | Fixed and portable | Mobility |

In the IEEE 802.16 standard, the first focus on application to the local network. But as a result of the advancement of wireless communications technology and the needs of the market, user-specific mobility features can guarantee a broader market. To support this wireless mobile broadband Internet service, the IEEE 802.16 workgroup offers the standard IEEE 802.16e standard, based on the IEEE 802.16-2004 standard, aiming to offer wireless broadband solutions. High speed data transmission

and high speed support Mobility only because IEEE 802.16e supports high-speed data. On the move, it is considered to be the next generation wireless broadband technology in the race to 3G. In addition to supporting mobile communications, the IEEE 802.16e also defines certain functions to disable connection features. Create mobile networks It also supports handoff, sleep mode, power saving, call search, and security updates. Table 2.1 is a comparison between the 802.16 standard. [4]

Pro:

- Already built-in Current Smart phone device
- Low Cost withing the range of the Access point
- Better Data communicatin Security

Con:

- Power need to increase if preferred more distance.
- Unstable in some frequency band interfearence
- If need more covered area then WIMAX or Mesh which higher cost

2.4 System Principle of Radio Frequency module

Radiofrequency communications may be the simplest form of communication between protocol devices, as used in ZigBee or Z-Wave devices. RF and low power consumption in embedded or modular electronic devices. The Z-wave distance is approximately 100 feet (30 m). The radio frequency spectrum is specific to the country. For example, Europe has an 868.42 MHz SRD band, ISM 900 MHz, or 908.42 MHz (US) to 916 MHz in Israel, 919.82 MHz in Hong Kong, 921.42 MHz in Australia / New Zealand) and 865.2 Mhz in India. Commonly used in the 915 MHz and 2.4 GHz. ZigBee is based on the IEEE 802.15.4 standard. IEEE 802.15.4 defines three operations that do not require a license.

In the spectrum (medical science industry, ISM) below is a summary table.2.2

Table 2.2 Zigbee specification [10]

| Property Description | Prescribed Values | |
|--|--|-------------|
| | 915 MHz | 2.4 GHz |
| Raw data bit rate | 40 kbps | 250 kbps |
| Transmitter output power | 1 mW = 0 dBm | |
| Receiver sensitivity (<1% packet error rate) | -92 dBm | -85 dBm |
| Transmission range | Indoors: up to 30 m; Outdoors: up to 100 m | |
| Latency | 15 ms | |
| Channels | 10 channels | 16 channels |
| Channel numbering | 1 to 10 | 11 to 26 |
| Channel access | CSMA-CA and slotted CSMA-CA | |
| Modulation scheme | BPSK | O-QPSK |

Two features of the IEEE 802.15.4 radio frequency ISM: 915 MHz band and 2.4 GHz. ZigBee basically uses digital radios to allow the device to communicate with each other. The typical ZigBee network consists of several types of devices. Coordinator of the Network is to set up a network. Perception of all the nodes in their network and the two executives. Information about each node, as well as the data that is sent / received within the ZigBee network. Everybody needs a network coordinator. Full Function Full Function Devices (FFDs) may be found in networks, and these devices support all 802.15.4 functions by which they can act as network coordinators. Or network devices that interact with the physical world. The last

devices found in these networks are the Reduced Function Device (RFD). Serves as the interaction with the physical world. As mentioned above, many supported by technology. ZigBee, including star (mesh), mesh and (TREE) cluster. Star structure is most useful when many end devices are located close together so that they can communicate with a single node router. The node can then be part of a larger mesh network, ultimately communicating with the network coordinator. The mesh network allows redundancy in node links so that if one node goes down, the device can find alternate routes to communicate with one another.

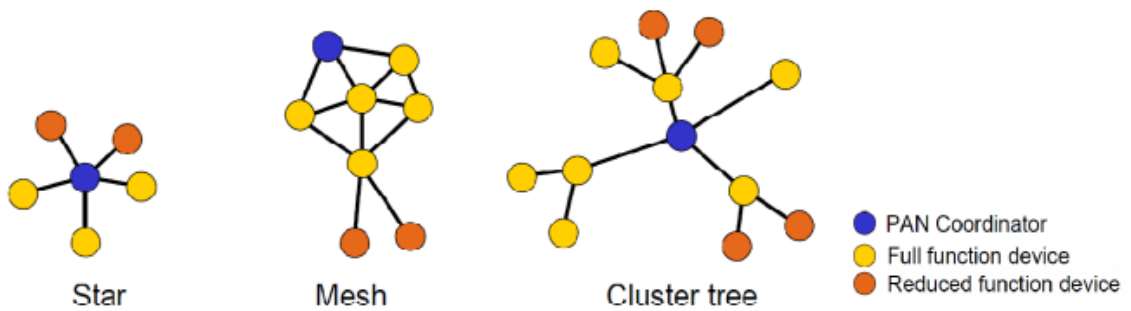


Fig. 2.8 Supported network interfaces 802.15.4 [10]

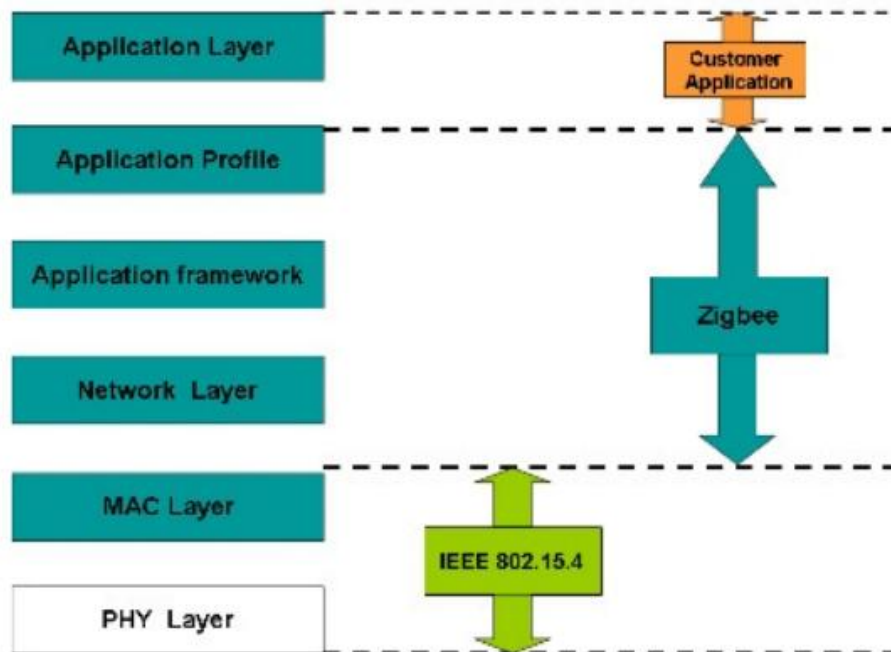


Fig. 2.9 ZIGBEE Stack on OSI Model [11]

As shown in Figure 2.9 above, a stack layer defined by the ZigBee specification is a network and application layer ZigBee frame. The stack is freely dependent on the OSI 7 layer model to be implemented, just listen. The necessary functions in the intended market.

Pro:

- Low power consumption compared to other communications. And do not have to rely on the system on the mobile phone system.
- Simple to communicate from point to point or point to many point to Star, Tree topology.
- Price is very cheap

Con:

- Communication distance between 30-100 meters.
- Low power consumption due to low power consumption.
- The Internet connection is still relatively new.

2.5 System Principle of Packet Radio by using APRS protocol

Bob Bruninga, senior research engineer at the United States Naval Academy, began developing APRS protocols on Apple II computers in 1982. This first version was used to map high frequency fleet navy reports. The first time that APRS was used was in 1984 when Bruninga developed a higher version of the Computer Commodore VIC-20 computer for reporting position and horse status in 100 miles (160 km) of patience. [14, 15]

The APRS protocol uses the principle of transmitting Packet Radio data, called AX-25. Digital data with all GPS signals are converted to two tone frequencies (Binary 1 represents 1200 Hz; Binary 0 represents 2200 Hz). As shown in Fig. 2.10 [15], the dual frequency of the data is transmitted to the microphone of the mobile radio or mobile phone and is transmitted as Binary Frequency Shift Keying (BFSK). At the end of reception, the demodulated data from the radio receiver is sent to the radio modem and is converted back to digital stream and decoded. The newly generated

data will be used to tell the coordinates of the station that sent the signal to appear in the mapping system or on the google map, and in many parts of the world will use the digipeaters used in the mapping system. Relay or forward until finally the data is connected to an Internet server (I-GATE) [47] in order to send data to several websites, for example, APRS.FI and Findu.com, which have been developed to allow users to access location information. These and can monitor APRS traffic in real time.

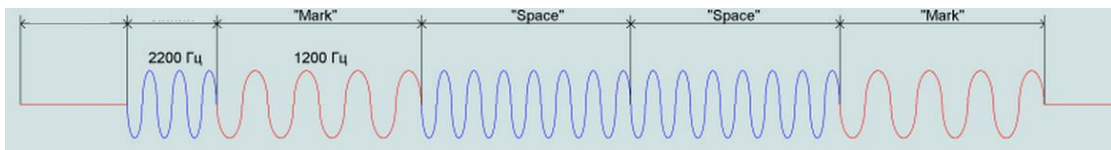


Fig. 2.10 Sample of AFSK, Double Frequency of Binary Data 1001 [50]

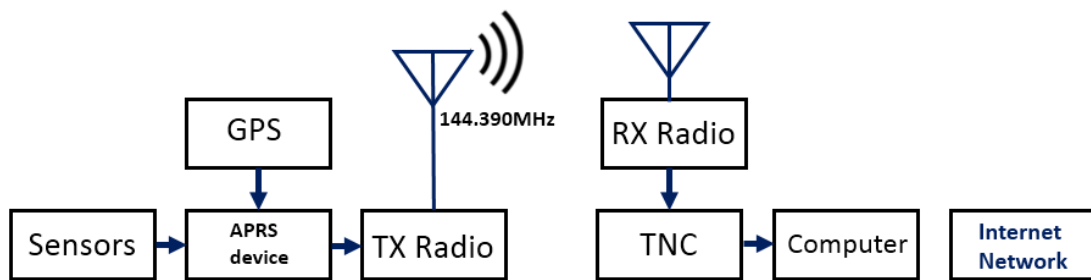


Fig. 2.11 Basic Principle of Packet Radio became APRS [14]

So what is APRS and why is it important? A brief guide to APRS is that the digital communication model used by Amateur radio which is a packet (The content is diverse. But this is usually a GPS position - which is what makes APRS the "Automatic Position Reporting System." [13-15] Figure 2.11 shows an end to end APRS system, which begins with GPS data communication using NEMA. [28] With the APRS tracker, the tracker then uses this information and configuration settings to determine APRS packets. The APRS packets are encoded by the tracker and the audio is transmitted to the radio transmitter, which sends data. Usually operated at 144.390MHz in Thailand. The NBTC allows radio receivers to receive the same frequency signal through the received voice to the TNC, which decodes the packets and transmits them to the computer using the same frequency by using RS-232 connection.

APRS It is real-time, suitable for field work as a protocol. Communications A digital model for exchanging information between a large numbers of large coverage stations. (Local) area as a data network, many users are quite different from conventional packet radio communications. The APRS differs from the normal packets in four ways. For the first time, by integrating maps and other information displayed in the organizing and display. Second, using one-to-many protocols to update everyone in real life. The third time, using general digipeating, was immediately available without pre-setting, and the fourth was that since 1997, the world has communicated across the Internet, linking everyone around the globe, and APRS is developing an open system in Packet Radio. Real time optimized for tactical communications and display systems for emergencies and with the application of public services. Normal Packet Radio is helpful in passing the traffic of bulk messages (e-mails) from one place to another. But it does not do well in realtime events where data has a very short period of time and the need to get it to everyone quickly. Distributed by APRS. Although the Internet is monitored by APRS worldwide, this is not a primary objective, but APRS in the event of an emergency or special event which is driving the development and design of the APRS protocol. 99% more in terms of data transmission over long distances and Realtime. Protocol conditions are designed to optimize performance for short-term transmission operations in real-time time intervals on radio frequencies.

APRS provides universal connectivity to all stations by avoiding the complexity and limitations of connected networks. By allowing any number of stations to exchange information, as well as voice users, it is on to talk to any station with voice and there is information to be involved, just send it and all the stations get it and input. Sign it. Second, APRS recognizes that, in the greatest real time, any special needs event or emergency case is a track of a major asset. Where do people find activities? Where the station is coordinates? Emergency vehicles? Weather at various points in the field? In order to answer these questions using APRS and capture the position and status of all stations. It can be used via any two-way radio system, including HAM, CB, navigational radio, etc.

In Thailand, the NBTC is required to use conditions that require a minimum radio license. In use by APRS is 144.390 MHz, as in the United States.

Basic APRS consist of:

- GPS Module
- Radio Module or Digital Conversion unit for BFSK (Binary Frequency Shift Keying)
- RF Module Transceiver (VOICE Radio)



2.5.1 Transmission of APRS signals

On VHF the APRS frames are transmitted in AFSK (Audio frequencies shift keying) or, to be more rigorous, in class F2D which means:

- F: frequency modulation
- 2: Single, digital signal, using a subcarrier
- D: Data transmission

The frequency used for APRS in Thailand (NBTC Plan) is 144.390 MHz. The modulating subcarrier can carry two tones, one corresponding to the Mark (1200Hz) and the other to the Space (2200Hz).

The bit rate is 1200 bits / s, which means that the duration of a mark or a space is 833 milliseconds, which is a period for the mark and a little less than two periods for the space. [58]

2.5.2 NRZI encoding

This type of encoding makes it possible to transmit binary information with good efficiency. The "0" and the "1" to be transmitted are not translated by different states of the transmitted signal but by changes of states of this signal at the time of a clock top: [58]

- The transmission of a "0" translates to the passage from Mark to Space (if the tone being transmitted was 1200Hz) or from Space to Mark (if it was 2200Hz)
- The transmission of a "1" consists in doing nothing at the time of the clock top.

Of course, the clock has a frequency of 1200 Hz to transmit 1200 bits per second.

The figure opposite shows:

- The clock signal with a pulse every 833 milliseconds
- The byte to be transmitted "10000010"
- The output signal from a logical point of view
- the output signal, a tone whose frequency varies from 1200 to 2200Hz at the time of the clock top if, and only if, a "0" is to be transmitted.

Note: the frequency change of the output signal is done without phase change.

It can be seen that a sequence of 1 does not result in a continuous tone, ie 1200 or 2200 Hz, which does not allow the decoding program to synchronize at the bit. That is why the sequels of more than five "1" are cut into pieces by insertion of "0". (see: "Bit-stuffing") [50]

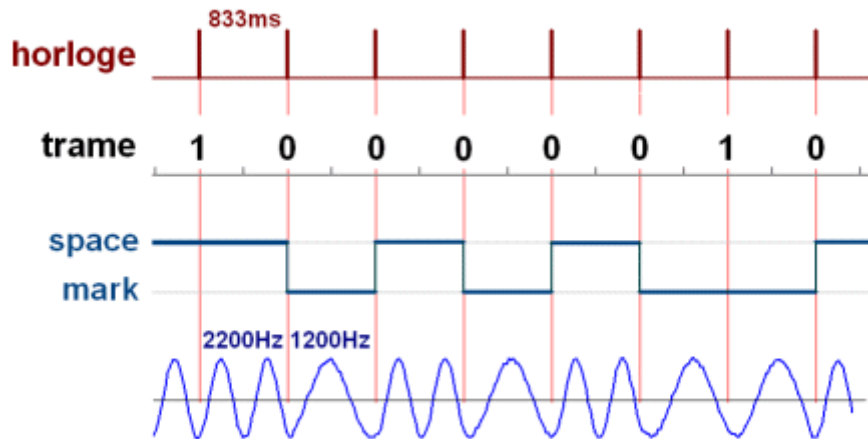


Fig. 2.12 AFSK vs Binary data [50]

In appearance, the content of an APRS frame varies greatly depending on whether certain information (geographical position) is present or not, compressed or not.

Example:

The following information, decoded by UI-View:

08: 21: 3 0R F4FEB> APFD25, WIDE1-1, WIDE2-2 Port = 2 <UI C Len = 51>: = 4723.26N / 00633.59E-PHG3630 / 73 all. {UIV32N}

Are actually transmitted in the form of a string that resembles:

APFD25 F4FEB WIDE1-1, WIDE2-2__4723.26N / 00633.59E-PHG3630 / 73 to all. {UIV32N}

But in reality, this string, the frame, is structured in a standardized way into several fields (9 in total), some of which have a fixed length and others a variable length.

2.5.3 Structure

The structure of an APRS frame is of the UI (Unnumbered Information) type defined according to the Amateur Packet-Radio Link-Layer Protocol (AX25)

The PDF document (see section "Documentation below the reference (101) schematically. [50]

Table 2.3 AX.25 UI-FRAME Format

| 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 |

Here are the details:

Flag: length 1 byte (one byte); It detects the start of the frame. Its value is immutable and equal to 7E in hexadecimal, or 01111110 in binary.

It does not appear in our example. In general it is not 1 but a whole series of flags that are issued before the start of the next field.

Destination Address: length 7 bytes. This field can contain a wide variety of values.

Example: **APFD25p**

Source Address: length 7 bytes. Indicator of the transmitting station of the frame followed by the SSID

Example: **F4FEB 0**

Digipeater Addresses (0-8): Length 0 to 56 bytes, which means that this field may be non-existent. Each digi address is coded on 7 characters.

Example: **WIDE1 1WIDE2 2**

Control Field (UI): length 1 byte. Fixed value 03 in hexadecimal that is 00000011 in binary.

Example: **_** (cannot be represented as an ordinary character)

Protocol ID: Fixed value equal to F0 in hexadecimal, or 11110000 in binary.

Example: **_** (cannot be represented as an ordinary character)

FIELD INFORMATION: length 1 to 256 bytes. The first character is the identifier, here a "<" which specifies that the following information relates to the station (here the position

Geographical and the PHG code giving the transmit power, the height and the gain of the antenna)

Example: <4723.26N / 00633.59E-PHG3630 / 73 all. {UIV32N}

FCS: length 2 bytes. It contains a 16-bit number to check that the frame has been transmitted without error.

It does not appear in our example

Flag: length 1 byte; It marks the end of the frame. Its value is immutable and equal to 7E in hexadecimal, or 01111110 in binary.

It does not appear in our example.

Note: The frame is normally preceded by a series (and not just one) of flags allowing the decoding program to prepare to receive it.

TRANSMISSION PATH

D) RF to internet / Network

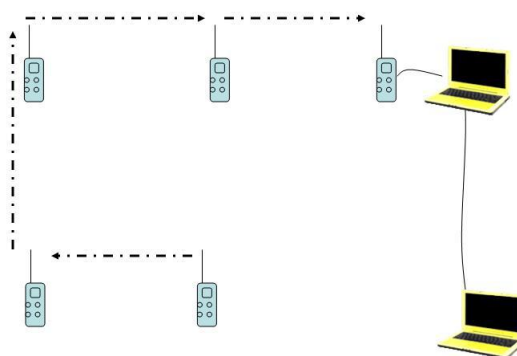


Fig. 2.13 Remote distribution of APRS data through I-Gates. [22]

If the signal is to be received and retransmitted from specific Digipeaters, we use their call signs in the corresponding field. By doing so, our transmissions can be

controlled in terms of spatial distribution: where and how far the transmission will go? (Foutzitzis, 2007)

Pro:

- Long distance communication depends on the use of transmitters and antennas that can be added without interfering with the entire system. Also, the distance with the Digipeater is up to 100 km.
- Suitable for peer to peer communication or point to too many points.
- Easy to install, no setup required.
- price is very cheap.

Con:

- Low bandwidth 1200 bps because of VHF / UHF radio.
- The Internet connection is also just another system as well.
- Programming for embedded development is quite complex.

2.6 Research of using APRS protocol to develop satellite communications.

According to Research by A ADDAIM, A KHERRAS (2005). NanoSattellite low price by this research. Design a system that takes APRS protocols to use. Demonstrate the use of APRS protocols that are capable of receiving and transmitting satellite data by receiving information from distant ground stations and forwarding them to another station. There are many unlimited terrestrial stations in the number that can be reached via the APRS protocol. As shown in Figure 2.14 [23]

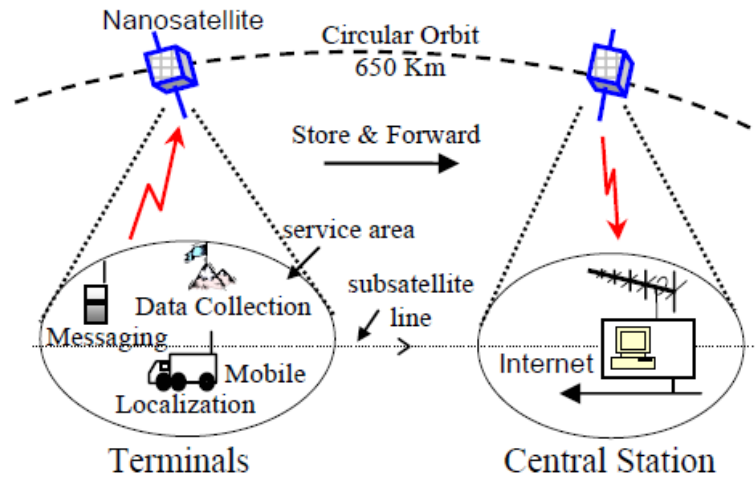


Fig. 2.14 APRS protocol for Store&Forward [23]

The terminal station is collecting data to send satellites through the Nano Satellite, where the use of people to send data is costly. However, satellite data transmission can be carried out between stations. There are more distances when satellites pass through.

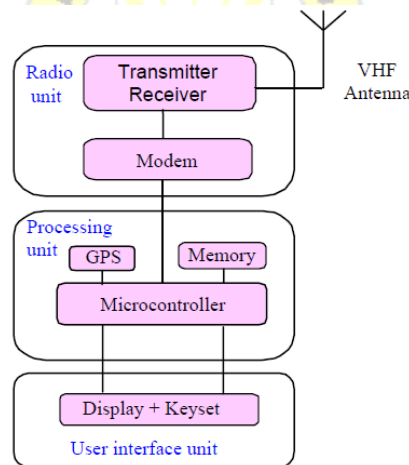


Fig 2.15 Detail Block Diagram of Terminal Station [23]

The terminal station consists of a set of embedded devices or an Embedded System through the microcontroller, via the transmitter through the transmitter. The satellite itself will calculate the orbit using the TLE (Two Line Element) data to calculate the location of the satellite in the sky accurately. The details of the components are shown in Figure 2.15. (M. Wirner, A. Jahn, E. Lutz and A. Bottcher, 1995)

Another important and necessary part of describing the components of a system using APRS. The protocol is the APRS component on a satellite called APRS payload, also known as OBDH (On Board Data Handling). Terminal Record to forward to the station at the bottom of the distance. Shown in Figure 2.16.

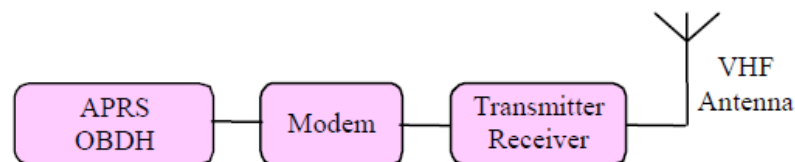


Fig. 2.16 Block Diagram on NanoSat [23]

The advantage of this research is that it offers the use of APRS protocol for long distance communications through the Earth's atmosphere to the space-sphere, with a small design effort. As small as possible, this research will be developed accordingly. There is also a compilation of calculations to determine the distance from the Earth to a satellite of more than 650 km, which can explain why APRS has the potential to be used in this research design.

2.7 Research of using APRS Protocol to detect Flash Flood

There is Weaver, J. A. (2005) researched by using APRS protocol to send the sensor data to detect Flash flood which is very useful and other Wireless Protocol can be able to perform in this situation. [49]

The following tasks were identified as the core requirements of the floodwater alert system:

- Monitor water level, recording all sensor data for later hydrological analysis and modeling
- Communicate sensor data to central monitoring facility located approximately 50 miles away
- Detect flood events early enough to give downstream communities time to evacuate

Autonomous monitoring stations, located above the bank of the river, will periodically poll these sensors using an error-resistant communication link. All sensors data will be logging to temporary storage. If the sensors indicate a flood, the

monitoring station will promptly alert downstream. Otherwise, the buffered sensor data will be burst-transmitted in a daily data upload. The use of multiple monitoring stations gives additional redundancy and the ability to track flood propagation speeds, though requires that the communication system correctly address multiple systems. [49]

The following text and Figure 2.17 [49] present a high-level design overview of the hardware satisfying these design goals. Subsequent sections describe individual components in greater detail and systematically work through major design decisions.

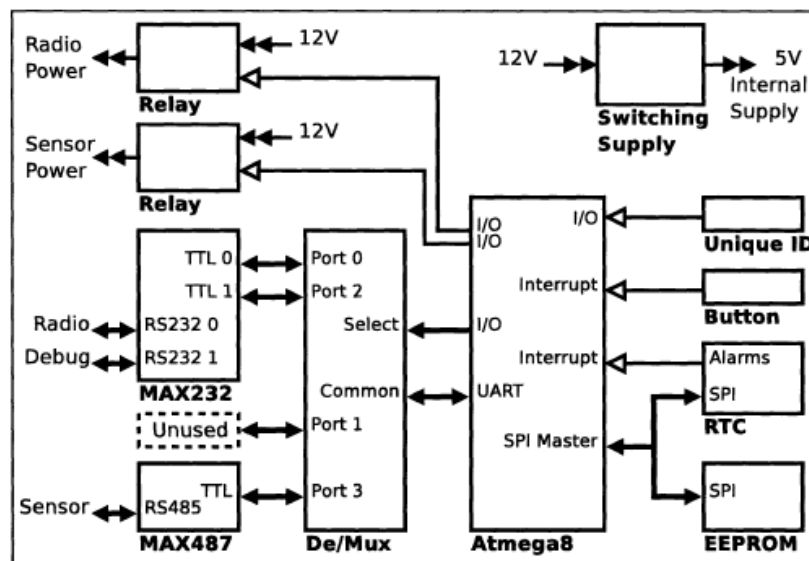


Fig. 2.17 Hardware design overview showing all ICs and major communication buses.

The APRS protocol uses a Status Report to announce a station's current mission or other single-line status to all receivers within range. Table 4.2 summarizes Chapter 16 "Status Reports" of the APRS Protocol Reference [14]

Table 2.4 Status report format [49]

| Field | Info | Time | Status Text |
|---------|----------------------|---------|-------------|
| Format | > | DDHHMMz | Text |
| Bytes | 1 | 7 | 0-55 |
| Example | >160900zRadio Online | | |

An APRS message is a text string with a specified addressee; a fixed 9-character field (padded with spaces if necessary) following the ":" data type identifier. The addressee field is terminated by another ":", then followed by the text of the

message. This message text can include any printable ASCII character, save for ", ~ {". The sender requests message acknowledgment by including the optional Message Identifier, which is composed of the "{" character, followed by up to five alphanumeric characters. The sending station will repeatedly transmit such a message until it receives an acknowledgment or times out. The receiving station uses a similar format for message acknowledgement, simply replacing the message text with "ack" followed by the five-character message ID. The central receiving site commands a monitoring station through five special APRS messages, shown in Table 2.4

The example that appeared in Table 2.4 shows a transmission from BASECAMP commanding SITE00001 to update its clock to transmitted timestamp and requesting acknowledgement. SITE00001 responds that it received the message, and thus performed the command.

APRS supports a standard telemetry data format used by a number of transceivers, and included in amateur rocketry and weather balloon projects. The full specification is described in Chapter 13 "Telemetry Data" of the APRS Protocol Reference [56] and summarized in Table 2.5:

Table 2.5 Telemetry Report Format [49]

| Field | Info | Sequence | Value 1 | Value 2 | Value 3 | Value 4 | Value 5 | Digital |
|----------------|--|----------|---------|---------|---------|---------|---------|---------|
| Format | T | #xxx, | aaa, | aaa, | aaa, | aaa, | aaa, | bbbbbbb |
| Bytes | 1 | 5 | 4 | 4 | 4 | 4 | 4 | 8 |
| Example | T#001,211,211,211,000,000,00000000 T#002,211,212,212,000,000,00000000 | | | | | | | |

- The Information field uses "T" to identify this message as telemetry data.
- The Report Sequence is a 3-character value, typically a 3-digit sequence.
- The receiving station can verify packet count and request that missing data be resent.
- There are five 8-bit unsigned analog data values (expressed as 3-digit decimal numbers in the range 000-255), followed by a single 8-bit binary number. Upon receiving the "Send Data" command from the base station, the system sends a status

Message announcing the start time of the collected data and the number of frames to be transmitted. Assuming the default rates for reading the sensors (6/hour), 24 hours of data is sent as 144 frames.

This limits the system to six attached sensors, or requires the Telemetry Format to be modified. If fewer sensors are attached, multiple data samples could be compressed into a single data frame to decrease transmission time. The example above shows the first two frames of a data sequence with three attached sensors reporting similar values.

This is the one of the interesting research project that put the APRS protocol in to the effective task.

2.8 Research Design and Implementation of Hardware for small-scale UAV helicopter

Cai, et.al. (2009) was intended to design the control system for UAV which the closest to this research system on how to control to be able to synchronize between Vehicle and control station or controller station. The design that explained in the FIG 2.16 the Software Module that can be similar to this research as the APRS decoding and send the command to control the movement or Motor driver. And the ground station should be able to send and receive the data communication on the traffic same as in their research from Cai, et.al. (2009) [47]

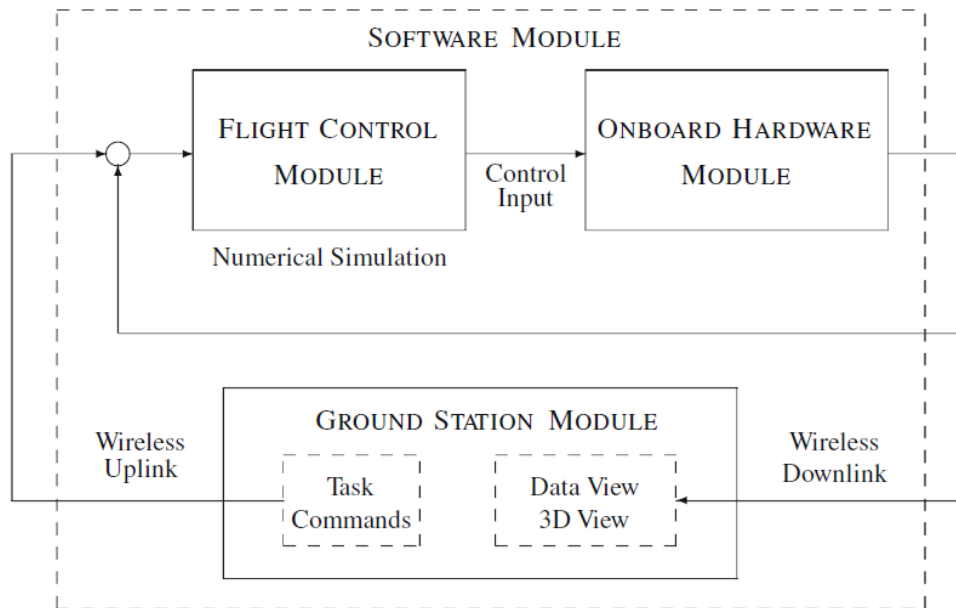


Fig. 2.18 Framework of the hardware UAV and Ground Station [47]

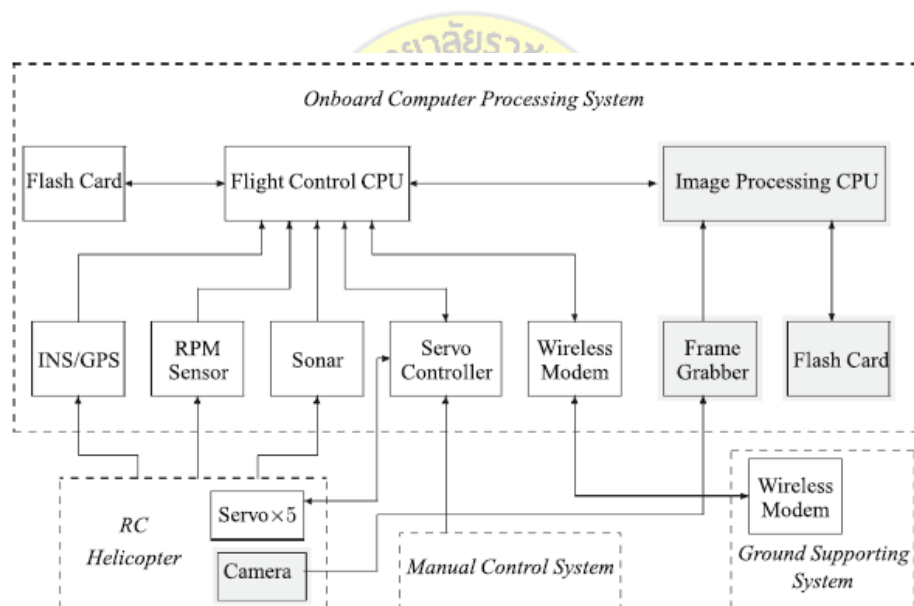


Fig. 2.19 Hardware configuration of the UAV helicopter system, [47]

Cai, et al. (2009) explained that on board electronic module that activates UAV servo actuators and output sensors; (b) a flight control module for executing automatic control algorithms; (c) a ground station module for generating task commands and monitoring the UAV through data view and 3D view interfaces; and (d) a software module for integrating all the previous three modules to perform real-

time hardware-in-the loop which this research will replace the data communication from their selected simple data telemetry in stead of using APRS protocol. [47]

2.9 End of chapter Summary

This chapter presents the options of various types of communication and APRS protocols. The protocol has been developed from the Packet Radio AX.25 since 1992, and this protocol has been developed for data communications with the requirements. Remote data transmission However, in the past, protocol design was limited to hard drives. The development of the device is possible, and large. The guidelines of this study. It is the improvement and design of the equipment using the side-system technology to represent a large device and have the power to not be installed on the device in the actual use. By comparing the size and education of existing systems, developing smaller and less energy-efficient applications, such as balloon delivery or installation work. CubeSat Satellite Content Especially this research. Will be experimenting with robots for remote surveying. So size is very important.

Advantages of doing software on embedded systems modulation as it incorporates the necessity of extra hardware; Instead, there are dedicated hardware intended for modifying and modulating APRS packets, with the ability to use more than TNC to do these tasks. It can provide a much cheaper solution for those who are interested in trying out APRS without having to invest a large initial investment (~ \$ 6000 for one hardware component. The price of this special hardware is steep and limited to effective communication only. It can be seen that the cost of using the APRS system in series 4 channels using dedicated hardware costs will be 24,000. The US, for all these costs, with a half-dozen design-side system that can be purchased, simply extends the capabilities beyond the price advantage of embedded systems with modulation. The main advantage if embedded software is used instead of hardware, it may be more capable of processing and increasing memory. For example, one of the only Kantronics KPC-3 hardware solutions has 512KB of memory compared to embedded systems that are designed to be all-in-one. [58] In addition,

instead of being able to handle fresh events and process information, each of the points in the best possible manner is as fast as possible.

Therefore, in this thesis, it is interesting to present the development of the device on the embedded circuit to enable data transmission capabilities using APRS protocols and applied in the remote communication network to collect data at the job. Various aspects, which were presented in the research already presented at the conference, such as Agricultural work Tree task tracking and task tracking tasks.

The next chapter will present the general theories related to theses, which will help to understand and explain the working principles of APRS protocols for development as a sensor reading device and GPS coordinates. Presented in this thesis. This research focuses exclusively on the APRS UNIT of these signals to see how software can be improved on the basis of an embedded system approach to encoding encoded by the APRS device.



Chapter 3

Research Methodology

In this research “Designing and Implementation Exploration Vehicle Remote Controller Using APRS. Protocol” has research methodology as below

3.1 Studying the concept of the APRS Protocol both Decoding and Encoding
Transferring the APRS protocol algorithm to the programming technique to selected Microcontroller

3.2 Designing the outline of entire system as below

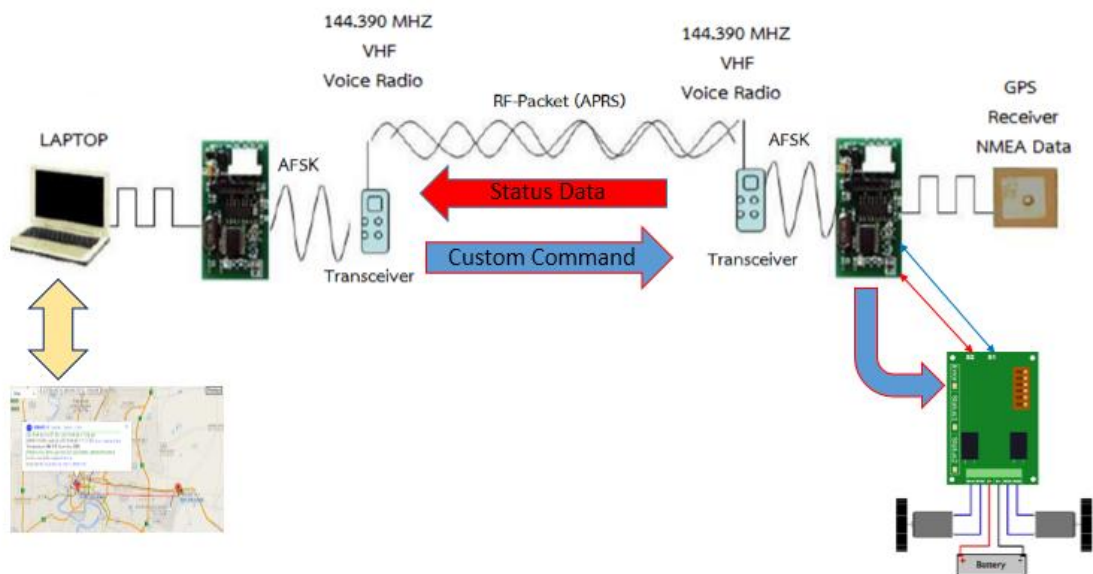


Fig. 3.1 Block diagram of system

3.3 Embedded Design for APRS protocol and Vehicle control schematic below:

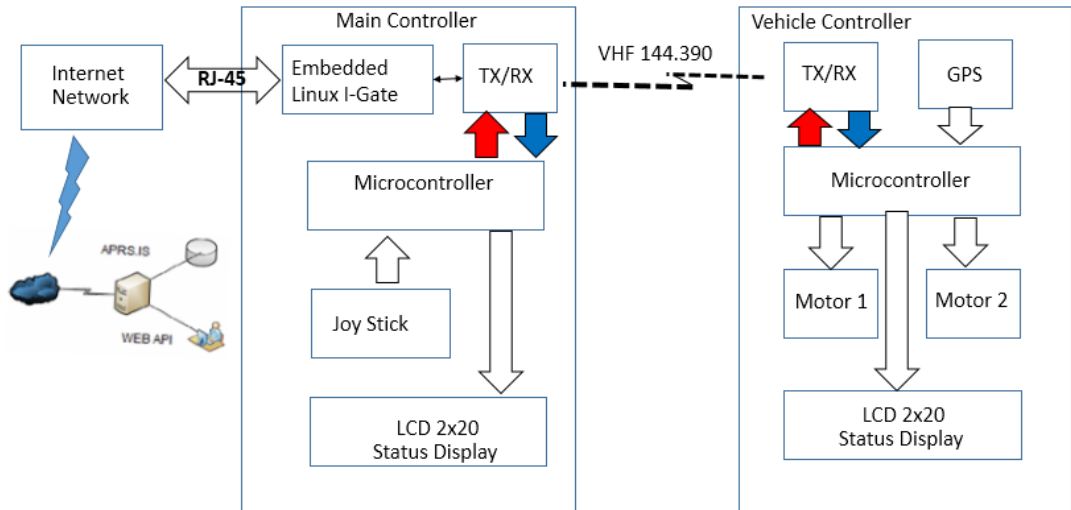


Fig. 3.2 Dataflow and programming flow diagram

3.4 Designing the Vehicle which will use to demonstrate the Custom command that will use to control the movement of the Vehicle

3.5 Implement the Base Station by using the Terminal Emulator to validation communication between Base station and Vehicle unit

3.6 Correcting result in 2 categories which are Distance and validation of correct response from vehicle

3.7 The result of the distance can be verified on the <http://aprs.fi/> and also determine of communication distance as the antenna propagation as fig below

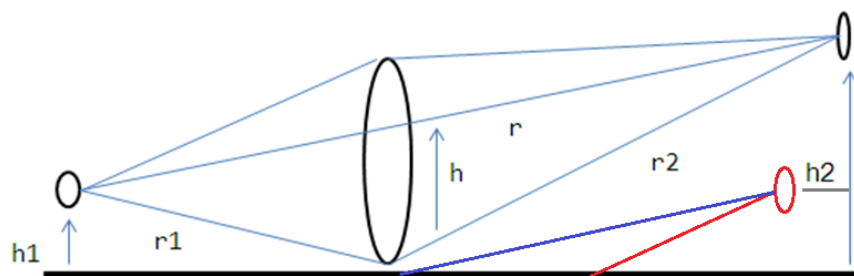


Fig. 3.3 explanation of the propagation above ground for Line of Sight (LOS)

Where h = height above plane, r = radial distance

Below is a comparison of the range achieved will using with this experiment with the theoretical values and our conclusions concerning the collective experiment metrics. The Link budget equation for the established link can be determined by the following equation 3.1 [29]

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} \quad (3.1)$$

Where:

P_{RX} = received power (dBm)

P_{TX} = transmitter output power (dBm)

G_{TX} = transmitter antenna gain (dBi)

L_{TX} = transmitter losses (coax, connectors) (dB)

L_{FS} = free space loss or path loss (dB)

L_M = miscellaneous losses (polarization mismatch, other losses) (dB)

G_{RX} = receiver antenna gain (dBi)

L_{RX} = receiver losses (coax, connectors) (dB)

3.8 Purposed Experiment Communication Data flow Diagram as fig below

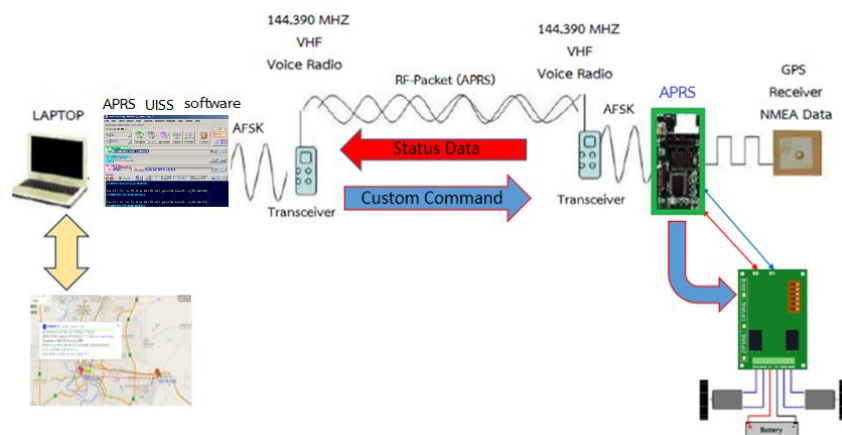


Fig. 3.4 Experiment design module

3.9 Custom Command set

As below for example that experiment need to validation the custom data that will send along the APRS as shown below for the method to create the command packet which will embedded into the AFSK that will send from Base/Ground Station to vehicle as below (Spencer,2016:online)

Example: Command to send over APRS for Robot Controller

“F100R085F050L030B045E”

Detail of the command set meaning as:

- *Forward 100 units*
- *Right 85 degrees*
- *Forward 50 units*
- *Left 30 degrees*
- *Backward 45 units*
- *End of command*



3.10 Experiment, Result and outcome

3.10.1 Should complete on how establish long distance network <10KM?

3.10.2 Should complete the Designing small embedded system with microcontroller to handle the communication?

3.10.3 Data Validation result with controlling and Datalog over the database server?

3.10.4 Should be able to create the custom command which use for remote Control the Exploration Vehicle in the remote distance?

Chapter 4

Designing Approach

4.1 Design Concept

The main idea of controlling vehicle at the long distance by using VHF Radio frequency and 2 ways data communication between ground station with terminal command or joystick and the vehicle module which maneuver the vehicle to move around and give the respond feedback to the ground station with GPS position in real time within the very long distance by using APRS. The AX.25 data Frame packet Radio protocol [14] used data communication speed at 1200 bps of APRS. The AX.25 is used then the information field by APRS packet radio networks, The AX.25 packets is transmitted using RF as carrier represent in OSI Model at Physical layer. AFSK (Audio Frequency Shift Keying) is used 1200Hz and 2200Hz Frequency Modulation represented logic 0 and 1. From the Figure 3.4 Explain on how the data link and communication in command mode working by Control station send command over the software UISS [59] which act as the terminal command but this software can generate AFSK and also can decode AFSK from the Vehicle unit sends respond Acknowledge message.

4.2 The vehicle system mode using APRS protocol data Frame

The Vehicle has two modes:

- **Beacon mode**, during the timer was programed that set to vehicle to send data in telemetry format (Temperatures and Battery voltage). This Position and sensor information data is converted into an APRS data frame format. The Position and Sensor Information data will be sent to a APRS.IS database server internet service and then be able to access by WEB Query over internet back to the Google map. In the Beacon mode the vehicle is sending the GPS data and other status of the Vehicle according to the timer parameter from the program APRS Data frame.

Table 4.1 data frame beacon mode [14]

| Field | Info | Time | Status Text |
|---------|---|---------|------------------|
| Format | > | DDHHMMz | Lat/Lon GPS Data |
| Bytes | 1 | 7 | 0-55 |
| Example | >160900z:1350.04N/10039.39E101/000/A=0001 | | |

- Command mode**, The Vehicle has been received command set from control station and then Vehicle unit will send acknowledge data from the MCU back to Control Station to let Control Station know the status of the Vehicle in order to maneuver the Vehicle to move left, right, forward, reverse. The Control mode, Receive and then validation the command from control station via VHF Radio frequencies and the command format used in the prototype control unit was transfer to control command for maneuver Vehicle, explain in Table II below:

Table 4.2 APRS Data Frame Control [14]

| Field | Info | Time | Status Text |
|---------|--------------------------------|---------|-------------|
| Format | > | DDHHMMz | Command |
| Bytes | 1 | 7 | 0-55 |
| Example | >160900z F300R045F050L045B045E | | |

This Data in Example field above can be translated to control vehicle command as example here: Forward 300 units, Right 45 degrees, Forward 50 units, left 45 degrees, Backward 45 units, End of command, unit can be arranged as the meter or feet.

4.3 Hardware Design

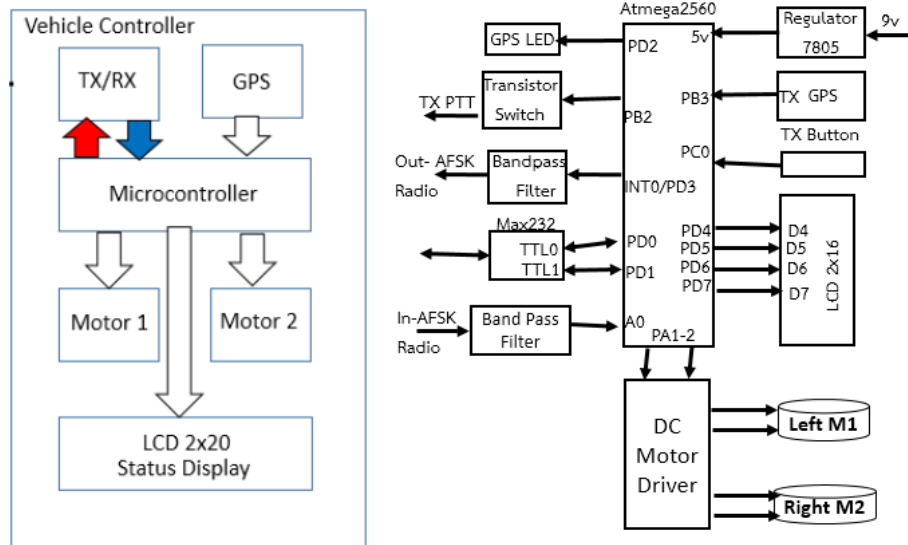


Fig. 4.1 Vehicle Control Hardware Block Diagram

- Microcontroller ATMEGA-2560[60] The 8-bit AVR model of RISC Microcontroller high-efficiency, low consumption power from Microchip 256KB Flash memory, 8KB Static Ram, 86 GPIO, 16-channel 10-bit A/D converter, 4 USARTs. Bootloader software which help to communicate with IDE or compiler already stored 5 KB, but most of the APRS protocol which Modem Encoder and Decoder also some of the program Routine that handle Input and output port and also multiple Serial port that can receive NMEA [61] data from GPS Module and also LCD display by selected this MCU still have plenty of memory and extend I/O port for future programming.

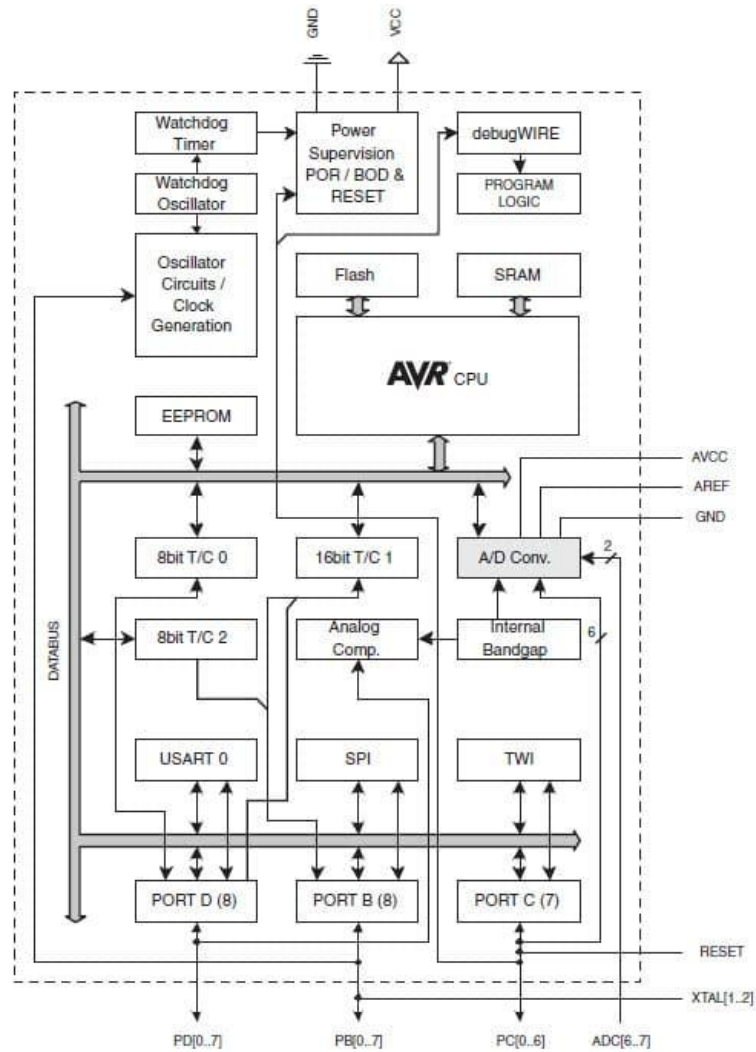


Fig. 4.2. AVR Microcontroller

- DC Motor Driver Sabertooth 2x25[62] 2 channel DC motor Driver which can drive up to 25A each channel. Maximum loads may be up to 50A per channel after receive input from MCU in PWM which can be programed from MCU.
- Band Pass Filter In order to generate Sinewave from MCU to have dual frequency by using PWM technique and then pass the signal to Band pass filter and then the output from Band pass become Sinewave that Audio needs a low-pass filter ($R=8.2k\Omega$ $C=0.1\mu$) plus DC Coupling ($C_c=1\mu$). This also lowers audio to 500mV peak-peak required by input of Transmitter Module or Transceiver.

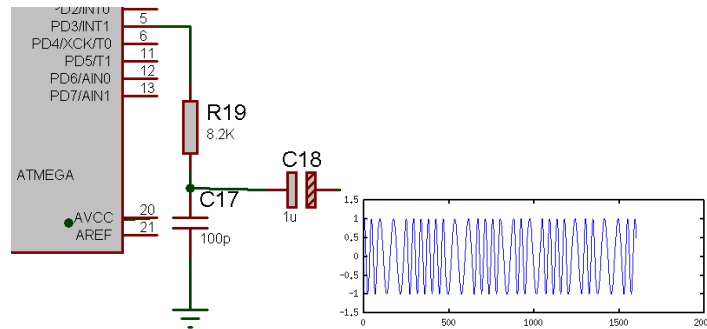


Fig. 4.3 output of AFSK from I/O passed Band Pass filter

4.4 Software Design

Software programming technique designed by using AVR Atmega family which explained in module as below Fig 4.3

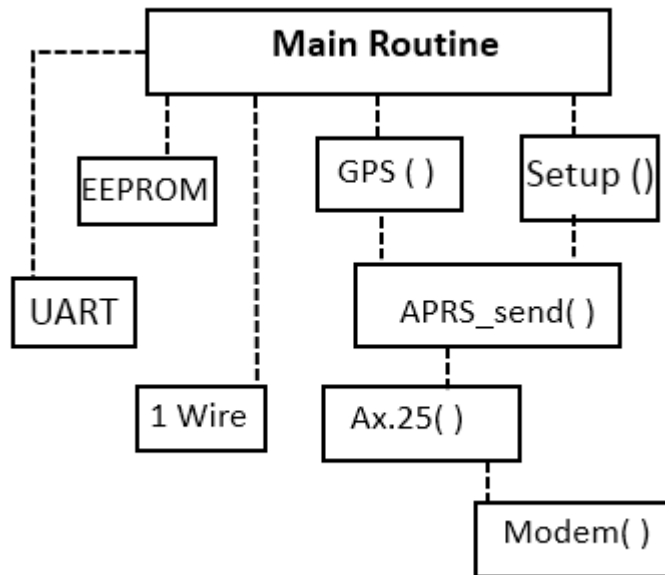


Fig. 4.4 Software Module hirachy

- **Beacon mode**, Programing the unit as the Beacon station which send the Position data (Lat/Lon) along with the health status of the Vehicle such as the Battery voltage level in the one data packet over APRS protocol can be explain in the Fig. 4.4

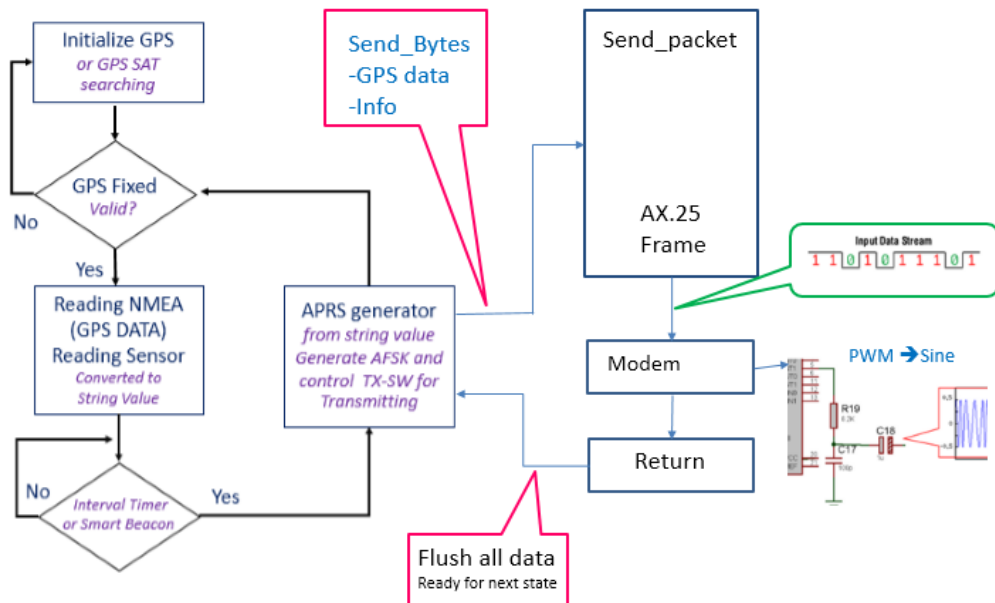


Fig. 4.5 Beacon programming techniques

The above description describes the programming in AVR. The main explanation is written in the section that writes the APRS by writing the Firmware. Conclusion comes in two parts, mainly in the first part is to convert the obtained data. In the form of a Data Frame, AX.25 requires a UI Frame, called an APRS format that has both front and back flags. The APRS AX.25 Waveform 1200Hz and 2200Hz models rely on the SINE waveform generator from PWM to convert that character into a waveform. From source data such as NMEA data, the coordinates come to convert it into data, and then return the Mirror data to the Audio Frequency Shift Keying (AFSK). Using PWM, the logic principle is to set the logic 1 frequency to 1200Hz and logic 0 to 2200 Hz. In the Figure 4.29 to explain binary sequence of 1001 modulated by AFSK.

In the first part of the program, we need to write a module that will be used to organize or convert the received data into a frame format. The frame can be sent to the AX.25 protocol, but the packet must be split. The seven sections are as follows:

Table 0.3 Data Frame Format

| Flag (BOF) | Address | Control | PID | Information (Data) | CRC | FLAG (EOF) |
|---------------|-----------|---------|-------|-----------------------|--------|---------------|
| 1byte | 14 to 70b | 1byte | 1byte | Up to 256b | 2bytes | 1byte |

- A. Flag (BOF)
- B. Address
- C. Control
- D. Protocol Identifier (PID)
- E. Information (Data)
- F. Frame Check Sequence
- G. Flag (EOF)

Most of the information below describes these fields as a summary of what appears in the AX.25 protocol description, which makes this content easier to explain what is required to transmit a UI frame.

A. Flags

FLAG is only a hex value of 7E (01111110 in binary form) that is sent indefinitely when no data is transmitted. For example, when setting TXdelay on your TNC to a certain value, it sends the flag (7E) repeatedly during that time. These FLAGS provide the receiver with a clear indication when one packet ends and the next starting point is the starting point. So there must be at least one flag between the two adjacent packets.

B. Address

Address field has a destination. (In this case, use the term CQ) source (W2FS-4 in this case) and no more than eight digipeters (in this case use the word RELAY). Each "callsigns" in the address field must contain 7 characters, 6 for callsign and 1 for SSID. If less than 6 characters are required In addition, the receiving station must have a method of checking when the address field is terminated. (Because it may have anywhere from 0 to 8 digipeters in it). This is

handled by shifting each bit one position to the left so that 0 appears to be the least significant bit. This bit is set to one for the SSID (seven bytes) or last callsign in the address field. For example, the destination callsign is encrypted as follows:

| Character | | HEX Value from ASCII Table | | Shifted Hex Value to Left |
|-----------|----|-------------------------------|----|------------------------------|
| C | 43 | (01000011) | 86 | (10000110) |
| Q | 51 | 01010001) | A2 | (10100010) |
| Space | 20 | (00100000) | 40 | (01000000) |
| Space | 20 | (00100000) | 40 | (01000000) |
| Space | 20 | (00100000) | 40 | (01000000) |
| Space | 20 | (00100000) | 40 | (01000000) |

The seventh SSID is a bit trickier. Use the following bit pattern: 011SSSSx by SSSS as SSID (as binary) and x as 0 if not the last callsign in the address field, and 1 if the last callsign is in the address field. Since the destination address in this case does not have an SSID (that is, SSID = 0) and not the last callsign, the value should be: 01100000 or 60 in hex.

Next is the callsign source, in which case this is "W2FS 4". Using the rules given above, we get the following string of bytes for this callsign:

| | | | | | | |
|----|----|----|----|-------|-------|---------------|
| W | 2 | F | S | Space | Space | ssid = 4 |
| AE | 64 | 8C | A6 | 40 | 40 | 68 (01101000) |

| | | | | | | |
|----|----|----|----|----|----|--------|
| R | E | L | A | Y | Sp | Ssid=0 |
| A4 | 8A | 98 | 82 | B2 | 40 | 61 |

C. Control and PID

Since we do only UI control frames and PID bytes, it is quite easy. Use 03 hexadecimal value for control byte and F0 value for PID byte.

D. Information

In this case, the data used is simply "Test", consisting of bytes (4 hex bytes) as follows:

| | | | |
|----|----|----|----|
| T | e | s | t |
| 54 | 65 | 73 | 74 |

The only thing to be careful about here is that these values are not scrolling left.

E. Frame Check Sequence (FCS)

The frame detection sequence (FCS) is a 16-bit number, calculated by both the sender and receiver of the frame. Used to ensure that frames are not damaged by the media used to receive frames from the sender to the recipient. Fortunately, there is a lot of information on the Internet about this calculation, which is often referred to as "CRC" rather than FCS. Instead of reviewing the CRC calculation theory, a simple mechanism to calculate this value. Used in assembly language. Instead of using a switch in C language, this code is included below in the code example used to write the FCS. In addition to Flag and FCS (which is further calculated), our test packet can be used as an array of 27 hex bytes (HEX) as follows:

Table 0.4 APRS Data Frame Format with Example data

| FLAG | Destination | Source | Digipeater Address | Control | PID | Information-Data | FCS | FLAG |
|------|-------------|--------|--------------------|---------|-----|------------------|------------|------|
| 7E | CQ | W2FS4 | RELAY | 03 | F0 | Test | Calculated | 7E |

| | | | | | | | | | | | | | |
|----------|----------|----------|----------|----------|----|--------|----------------|------------|----------|----------|----------|----------|----------|
| C | Q | Sp | Sp | Sp | Sp | Ssid=0 | W | 2 | F | S | sp | sp | Ssid=4 |
| 86 | A2 | 40 | 40 | 40 | 40 | 60 | AE | 64 | 8C | A6 | 40 | 40 | 68 |
| R | E | L | A | Y | Sp | Ssid=0 | <i>Control</i> | <i>PID</i> | | T | e | s | t |
| A4 | 8A | 98 | 82 | B2 | 40 | 61 | 03 | F0 | | 54 | 65 | 73 | 74 |

Transfer in to the C Array command format as below

```
byte SendData[27] = {0x86, 0xA2, 0x40, 0x40, 0x40, 0x40, 0x60, 0xAE, 0x64, 0x8C, 0xA6, 0x40, 0x40, 0x68, 0xA4, 0x8A, 0x98, 0x82, 0xB2, 0x40, 0x61, 0x03, 0xF0, 0x54, 0x65, 0x73, 0x74};
```

Example on C programing

After decoded with C code, which sends our sample array as AX.25's UI Frame. This code is written exclusively for use with C compilers that use the Arduino Boot loader, which is the C compiler that is included with the C compiler. The IDE can be

downloaded for free. As noted above, the same logic flow can be used to send a UI frame starting with an overview. The following function sends the packet contained in the Array SendData

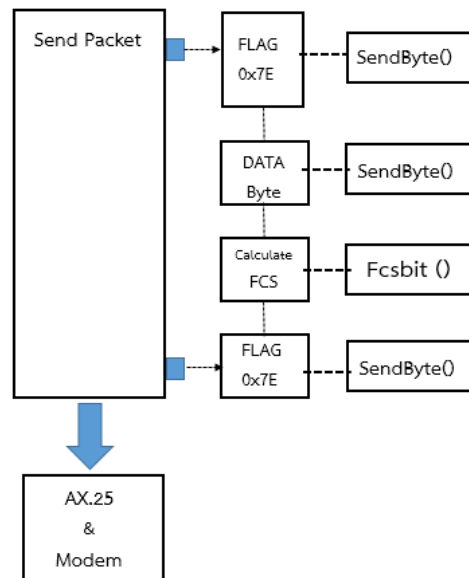


Fig. 4.6 hierarchy of functions used to create Frame Data AX.25.

- Function **SendPacket**

```

void SendPacket(void){
    fcslo=fcshi=0xFF; // 2 FCS Bytes begin with 0xFF (FFh)
    stuff = 0; //The variable stuff counts the number of 1's in a row. When it gets to 5
                // it is time to stuff a 0.
    output_high (PTT); // send output from AVR for pressing PTT
    flag = TRUE;
                //The variable flag is true if you are transmitted flags (7E's) false
    otherwise.
    fcsflag = FALSE;
                //Variable fcsflag = true then send FCS bytes, or FALSE no sending
    for(i=0;i<20;i++) (SendByte(0x7E)); //Send flag bytes. Adjust the range of txdelay
                //Each flag approx 6.7 ms
    flag = FALSE; //Send flags completed
    for(i=0;i<27;i++) (SendByte(SendData[i])); //sending packet bytes
  
```

```

fcsflag = TRUE;           //sending FCS bytes
fcslo =fcslo^0xff;       //doing XOR with FF before send
fcschi = fcshi^0xff;
SendByte(fcslo);         // sending low byte of FCS
SendByte(fcshi);         // sending high byte of FCS
fcsflag = FALSE         // finished send FCS
flag = TRUE;             //sending flags
SendByte(0x7e);          // send flag = end of packet
output_low(PTT);        // release PTT = stop on Air
}

```

The key of the SendPacket function is the SendByte function, which is called to send each 27 bytes from the Array SendData. This is the SendByte function: it is in the AX.25 () module.

- Function **SendByte**

```

void SendByte (byte inbyte){
int k, bt;
for (k=0;k<8;k++){           //counting for 8 bits = byte
    bt = inbyte & 0x01;      //Cutting right bit of Byte for Sending (inbyte)
    if ((fcsflag == FALSE) & (flag == false)) fcsbit(bt);
                                // FCS calc, when if true
                                // if not FLAG or fcs byte
    if (bt == 0) flipout();    // if this bit = 0 then convert to output
    else {                     // then
        stuff++;              // Increase +1
        if ((flag == FALSE) & (stuff == 5)){ //stuff inc 0, if = 5 1's in row
            delay_us(850);    //added Delay to match sending speed = 1200 baud
            flipout();        // convert the output status = 0
        } //end of if
    } //end of else
    inbyte = inbyte>>1;      //go to the next byte
    delay_us(850);           // added Delay to match sending speed = 1200 baud
} //end of for

```



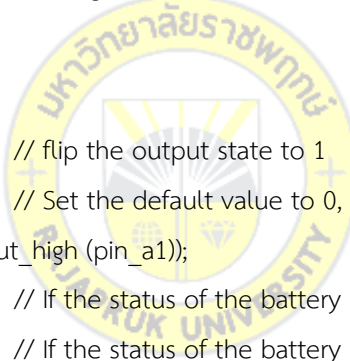
```
}/end of SendByte
```

For each data byte, a bit is transmitted at least. (That is, from right to left instead of left to right). The `delay_us` function is a routine that ships with compiler C. It should generate a delay of 850 microseconds. It may be thought that this period is too long since 1200 baud follows. Normally, each bit has a time of 833 milliseconds (1 second / 1200) the timing of the compiler timings is not accurate. The experiments found that the value of the function of C compiler at 850, which results in a correct time for 1200 baud.

- **Function `flipout`**

The `flipout` function will change the status of the outgoing transmission when it is zero. Are as follows:

```
void flipout () {
    stuff = 0;
    if (! bit_test (port_a, 1)) (output_high (pin_a1));
    else (output_low (pin_a1));
}
```



Finally, we need to actually calculate the FCS FCS calculations consist of two bytes, which are called `fcslo` and `fshi`. Both of these are set to FF. In this example, FCS is calculated step by step. There are algorithms that can calculate FCS either bytes, bytes, or bytes. Here are the steps to calculate:

- Function **fcsbit**

```

void fcsbit (byte tbyte) {
    #asm
        BCF 03.0 // assembly language
        RRF fcshi, F // rotate all of 16 bits
        RRF fcsl, F // to the right
    #endasm
    if ((status & 0x01) ^ (tbyte)) == 0x01 {
        fcshi = fcshi ^ 0x84;
        fcsl = fcsl ^ 0x08;
    }
}

```

tbyte, the parameter of the function is 0000 bytes or 0001 bytes that match the value of the transmitted bit (between #asm and # endasm). Since there is no easy way to rotate a 16-bit value using the three C constructs, The assembly simply moves one 16-bit value to the right, with the least significant bit previously placed in register bit 0 in the AVR chip. The next line (the line that begins with if) will process If the result is equal to 1, the FCS is XOR-ed with a hex value of 8408. If the result is 0, the last step is not done. Either way, the new values of FCS are preserved in fcshi and fcsl. This process may seem complicated, but it works.

By the process of programming, the data can be transformed from binary data into ASFK. It requires calculations from the equation. The Sine wave frequency is calculated as the carrier signal. Creates a continuous phase and in each letter is changed from Binary. It must not be broken and will be absent when the message ends. By changing the movement of the INDEX or the pointer to move on, or so-called Phase Delta, it is not necessary to calculate the range of 1200 or 2200 Hz.

PHASE_DELTA_XXXX values [64] Equation 4.1. The program is called in the receiving of information in the letters or numbers that come with the data is either Byte or String and to convert it to Binary 0 or Binary 1 of Byte is the frequency out by calling out. The formula and the table. Sine to generate two frequencies that represent Binary 0-1.

$$SE_DELTA_Fg = Tt*(Fg/Fm) \quad (4.1)$$

When

Tt = sine table size (TABLE_SIZE)

Fg = frequency of the output tone (1200 or 2200)

Fm = sampling rate (PLAYBACK_RATE_HZ)

Using DDS (Direct Digital Synthesis Technique) [65] technique in this simple format, a stable clock creates programmable memory. Programmable-read-only memory (PROM), which stores one or more cycles of sine. Since the address counter is transmitting through each memory location, the corresponding digital signal width at each position makes the DAC drive, which generates an analog output signal. The final spectral purity of the analog signal is determined by the DAC. The phase noise is the basis of the reference clock. The basic principles are as follows.

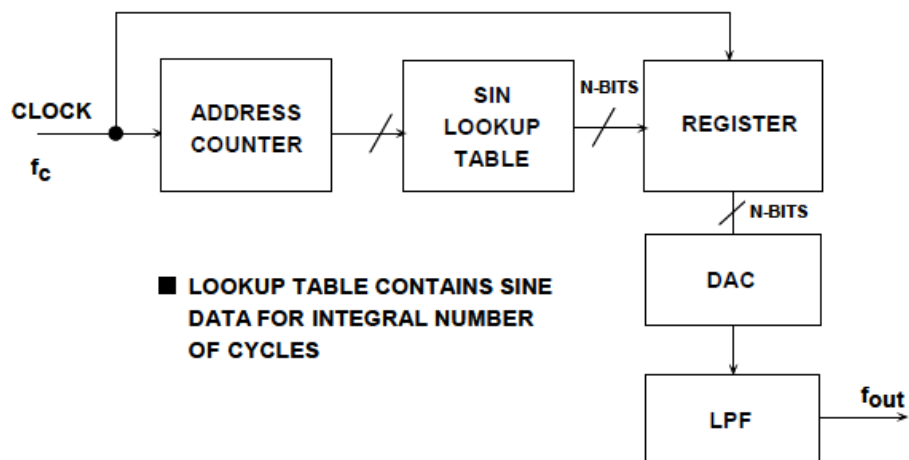


Fig. 4.7 DDS (Direct Digital Synthesis) technique

This easy-to-use DDS system is Final Frequency, can be changed only by changing the reference clock frequency or by Reprogramming PROM (Sine Table) is a useful DDS strength to use as a basic, flexible, and powerful function. Using hardware to image Sine Look up Table provides consistent digital amplitude information for the complete cycle. One of the look up table sinewave. The driver for the DAC is shown by "Phase Wheel".

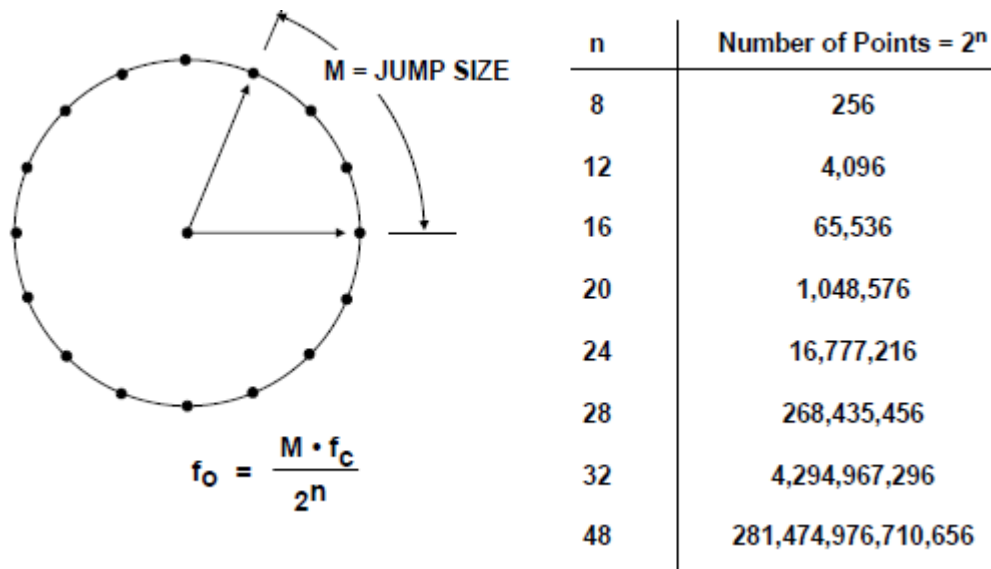


Fig. 4.8 Digital Phase Wheel [65]

By the corresponding sinewave frequency, the output is equal to the frequency of the input signal divided by 232. If $M = 2$ the phase accumulator register accumulator will "rolls over" twice faster and the output frequency doubles.

```

PROGMEM const prog_uchar sine_table[512] = {
  127, 129, 130, 132, 133, 135, 136, 138, 139, 141, 143, 144, 146, 147, 149, 150, 152, 153, 155, 156, 158,
  159, 161, 163, 164, 166, 167, 168, 170, 171, 173, 174, 176, 177, 179, 180, 182, 183, 184, 186, 187, 188,
  190, 191, 193, 194, 195, 197, 198, 199, 200, 202, 203, 204, 205, 207, 208, 209, 210, 211, 213, 214, 215,
  216, 217, 218, 219, 220, 221, 223, 224, 225, 226, 227, 228, 228, 229, 230, 231, 232, 233, 234, 235, 236,
  236, 237, 238, 239, 239, 240, 241, 242, 242, 243, 244, 244, 245, 245, 246, 247, 247, 248, 248, 249, 249,
  249, 250, 250, 251, 251, 251, 252, 252, 252, 253, 253, 253, 254, 254, 254, 254, 254, 254, 254, 254, 254,
  254, 254, 255, 254, 254, 254, 254, 254, 254, 254, 254, 254, 253, 253, 253, 253, 252, 252, 252, 251,
  251, 251, 250, 250, 249, 249, 249, 248, 248, 247, 247, 246, 245, 245, 244, 244, 243, 242, 242, 241, 240,
  239, 239, 238, 237, 236, 236, 235, 234, 233, 232, 231, 230, 229, 228, 228, 227, 226, 225, 224, 223, 221,
  220, 219, 218, 217, 216, 215, 214, 213, 211, 210, 209, 208, 207, 205, 204, 203, 202, 200, 199, 198, 197,
  195, 194, 193, 191, 190, 188, 187, 186, 184, 183, 182, 180, 179, 177, 176, 174, 173, 171, 170, 168, 167,
  166, 164, 163, 161, 159, 158, 156, 155, 153, 152, 150, 149, 147, 146, 144, 143, 141, 139, 138, 136, 135,
  133, 132, 130, 129, 127, 125, 124, 122, 121, 119, 118, 116, 115, 113, 111, 110, 108, 107, 105, 104, 102,
  101, 99, 98, 96, 95, 93, 91, 90, 88, 87, 86, 84, 83, 81, 80, 78, 77, 75, 74, 72, 71,
  70, 68, 67, 66, 64, 63, 61, 60, 59, 57, 56, 55, 54, 52, 51, 50, 49, 47, 46, 45, 44,
  43, 41, 40, 39, 38, 37, 36, 35, 34, 33, 31, 30, 29, 28, 27, 26, 26, 25, 24, 23, 22,
  21, 20, 19, 18, 18, 17, 16, 15, 15, 14, 13, 12, 12, 11, 10, 10, 9, 9, 8, 7, 7,
  6, 6, 5, 5, 5, 4, 4, 3, 3, 3, 2, 2, 2, 1, 1, 1, 1, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  2, 2, 2, 3, 3, 3, 4, 4, 5, 5, 5, 6, 6, 7, 7, 8, 9, 9, 10, 10, 11,
  12, 12, 13, 14, 15, 15, 16, 17, 18, 18, 19, 20, 21, 22, 23, 24, 25, 26, 26, 27, 28,
  29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 49, 50, 51, 52,
  54, 55, 56, 57, 59, 60, 61, 63, 64, 66, 67, 68, 70, 71, 72, 74, 75, 77, 78, 80, 81,
  83, 84, 86, 87, 88, 90, 91, 93, 95, 96, 98, 99, 101, 102, 104, 105, 107, 108, 110, 111, 113,
  115, 116, 118, 119, 121, 122, 124, 125
};

static const unsigned char REST_DUTY      = 127;
static const int TABLE_SIZE             = sizeof(sine_table);
static const unsigned long PLAYBACK_RATE = F_CPU / 256; // 62.5KHz @ F_CPU=16MHz of Atmel ATmega328
static const int BAUD_RATE               = 1200;
static const unsigned char SAMPLES_PER_BAUD= (PLAYBACK_RATE / BAUD_RATE);
static const unsigned int PHASE_DELTA_1200 = (((TABLE_SIZE * 1200L) << 7) / PLAYBACK_RATE);
static const unsigned int PHASE_DELTA_2200 = (((TABLE_SIZE * 2200L) << 7) / PLAYBACK_RATE);

```

Fig. 4.9 ARRAY of the Dual frequency Sinewave

Audio with an AVR and PWM: The ATmega328 chip or AVR does not come with a DAC (Digital-to-Analog Converter). So two options to create an analog signal are the PWM resistor or ladder. 4bit bit, but it seems to be more stable than if using PWM would be more complicated in programming. It requires a few external components and only one outgoing pin for the transmitter to transmit the radio as AFSK.

Great technique used to enable PWM generators to create SINE logic in Microcontroller. There are 3 timers that can do PWM. Some timer functions in Library. Timer 1 and 2 have the same capabilities, but Timer 1 can count up to 16 bits, and Timer 2 will increase to only 8 bits. By Michael Smith to create a PWM with an AVR and two timers using Timer 1 to sample (At the sample rate) and Timer 2 do the actual PWM (at the highest possible rate of 16 MHz / 256 = 62,500 Hz sampling rate), but by making the signal short-circuiting possible, it is possible to Do just one

timer and reduce the complexity of the code. All it takes is to tell the AVR to call into the interrupt queue when the PWM overflow timer and enter the sample from the interrupt routine. The ISR routine is called every 256 clock cycle, but that is long enough for the Sine Table to be used. Use the entire table as the SINE table, with a flow that describes the behavior of the `APRS_send()` routine in Figure 4.10.

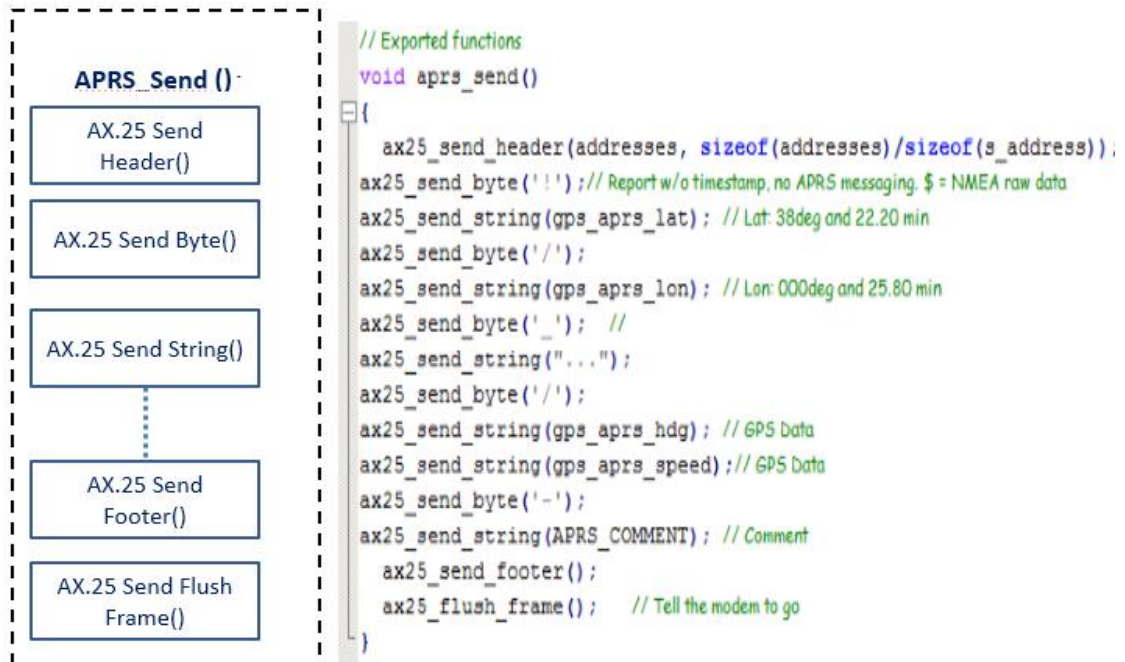


Fig. 4.10 Routine program for Byte sending control

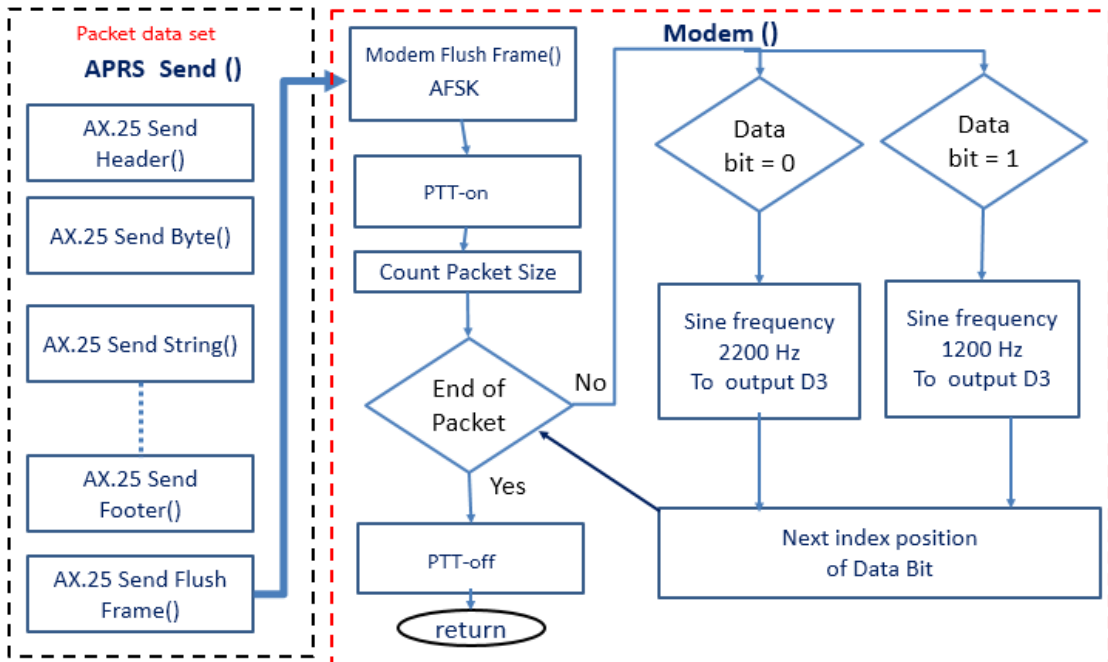


Fig. 4.11 Programing Flow of AFSK encoding technique

The details of the command are shown in Figure 4.11, Modem () will require that the Interrupt command set to Timer 2 set to Mode, then start Modem_start () when sending AFSK output pin and when. Interrupt must be stopped when transmission is complete by ordering Modem_Stop () and output from PWM pin.

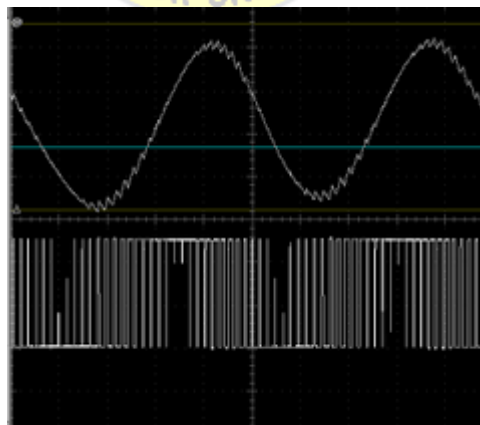


Fig. 4.12 PWM filtered and Unfiltered

- Command mode**, The Vehicle is always in standby to receive command from Control station then decode the valid APRS packet then convert data into the PWM signal [63] send to the Sabertooth DC motor Driver board and after the Motor performed steering as the command required then send back the acknowledge data to the APRS encoder routine in order to let the Control Station know the completed process which explain in Fig. 4.13.

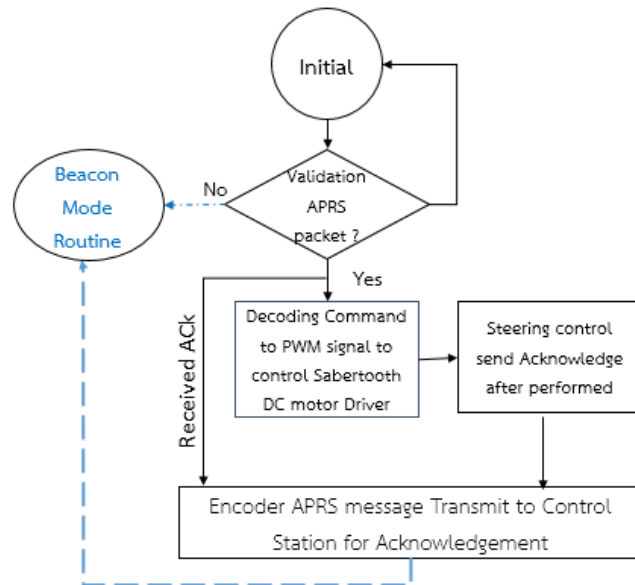


Fig. 4.13 Vehicle steering programming techniques

4.5 Vehicle Hardware Design

The design for the Vehicle Chassis consist of Aluminum Frame which can be able to hold 2 of 5 Amps DC. Motor installed with 10” rubber wheel and attached 1 small support wheel. In order to steer the Vehicle left and right direction using mixed mode, When the S_1 and S_2 received PWM signal fed to turn left or right of the Motor on each side will turning in the opposite direction same as the Tank Direction controller which help to maneuver to turn in very narrow radius as shown the designed diagram in Fig. 4.14.

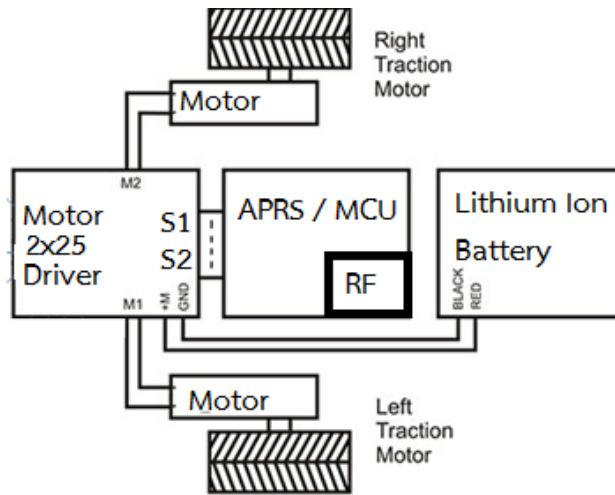


Fig. 4.14 Vehicle Hardware design

4.6 Control Station Configuration

The center of this operation base on the Terminal Control station send command over the software UISS By connecting an audio cable between the computer sound card microphone and earphone jacks to the Transceiver which attached to the ¼ wave Antenna at 45 meters above ground. The commands transmitted on the computer terminal will be received by the packet program then sent via the VHF transceiver to the vehicle.

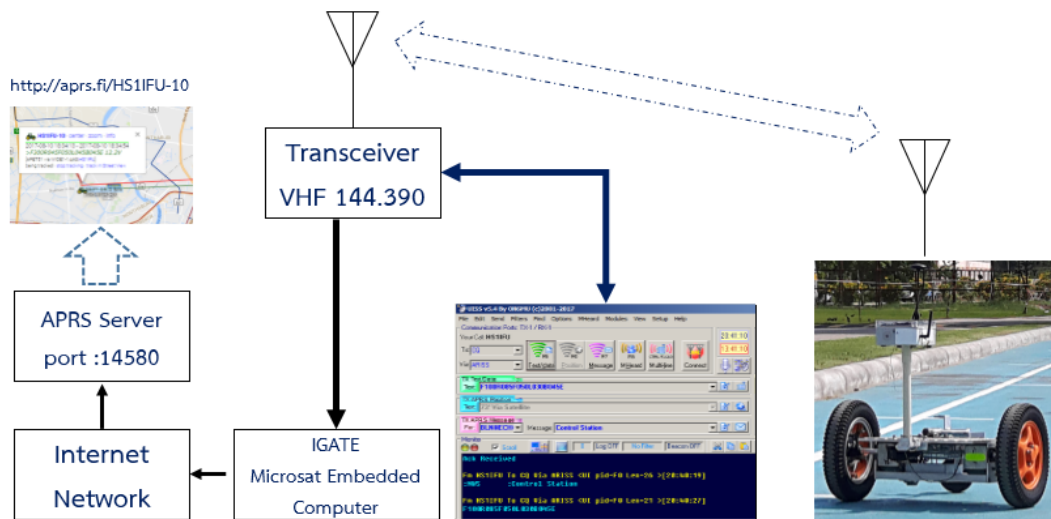


Fig. 4.15 Ground station configuration

Command to send over APRS for Robot Controller

“F300R045F050L045B045E”

Detail of the command set meaning as:

- *Forward 100 units*
- *Right 45 degrees*
- *Forward 50 units*
- *Left 45 degrees*
- *Backward 45 units*
- *End of command*

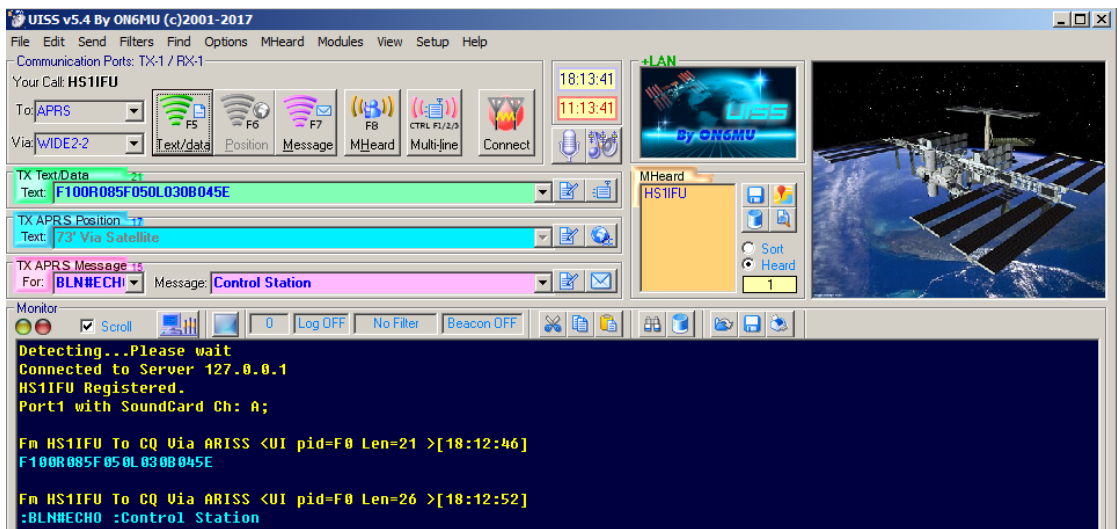


Fig. 4.16 UISS screenshot

Chapter 5

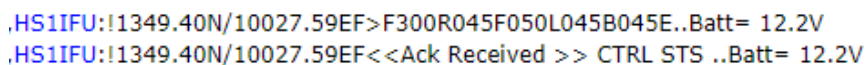
Result and Summary of Experimental

5.1 Beacon Mode experiment

In the beacon mode, the vehicle was programmed to send out the position data (Lat/Lon) and other status such as battery level by using APRS protocol using Radio Frequency VHF 144.390 MHz and the Control Station should be able picked up or received the APRS data in the expected range and the data can be queried via WEB tool <http://aprs.fi/HS1IFU-10>.

5.2 Control mode experiment

In this mode, the vehicle was in the main program that looping for receive command sending from the Control station which using UISS terminal software encoding all the command into APRS protocol and then the MCU that performed to decode the APRS packet into the data match to the command set which we assigned for the steering Vehicle and send back the Acknowledge back to Control station screenshot as show in Figure 5.1 below.



```
.HS1IFU:!1349.40N/10027.59EF>F300R045F050L045B045E..Batt= 12.2V  
.HS1IFU:!1349.40N/10027.59EF<<Ack Received >> CTRL STS ..Batt= 12.2V
```

Fig. 5.1 Screenshot of Decoded RAW Data

Raw data which receive by the MCU from the Control station can be decoded in Hex data which example data on Figure 5.2

```

2017-08-10 21:53:06 ICT HS1IFU-10: 84 bytes
0x00 H S 1 I F U - 1 0 > A P E T 5 1 , W I D E 1 - 1 , q A S , H S 1
      4853314946552d31303e4150455435312c57494445312d312c7141532c485331
0x20 I F U : ! 1 3 4 9 . 4 0 N / 1 0 0 2 7 . 5 9 E F > F 3 0 0 R 0 4
      4946553a21313334392e34304e2f31303032372e353945463e46333030523034
0x40 5 F 0 5 0 L 0 4 5 B 0 4 5 E 1 2 . 2 V
      35463035304c30343542303435452031322e3256

2017-08-10 21:55:06 ICT HS1IFU-10: 86 bytes
0x00 H S 1 I F U - 1 0 > A P E T 5 1 , W I D E 1 - 1 , q A S , H S 1
      4853314946552d31303e4150455435312c57494445312d312c7141532c485331
0x20 I F U : ! 1 3 4 9 . 4 0 N / 1 0 0 2 7 . 5 9 E F A c k R e c e
      4946553a21313334392e34304e2f31303032372e3539454641636b2052656365
0x40 i v e d > > C T R L S T S 1 2 . 2 V
      69766564203e3e204354524c205354532031322e3256

```

Fig 5.2 Screenshot of Decoded data in Hex

WEB Interface APRS Database Query tool that already available by other Web Developer that there are several Web Access software available online with but at this time, accessing to Web access will use one of the popular APRS Database query web access called <http://aprs.fi/ssid> SSID (Sub Station Identifier) of this vehicle is "HS1IFU-10" which is <http://aprs.fi/HS1IFU-10>

5.3 Experimental Result

The Testing result as Figure 10 appeared overlay Google Map tool had shown distance of communication from Vehicle to I-Gate (Control Station) range achieved 19 kilometers between Control Station with antenna installed 45 meters above ground and the vehicle unit location.

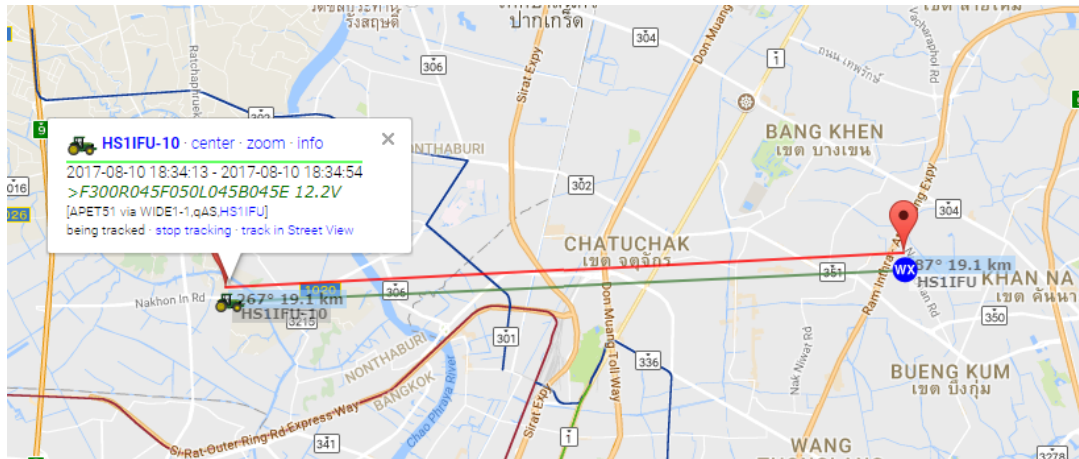


Fig. 5.3 Google Map API tools over the Web Query Interface

5.4 Link Budget Calculation

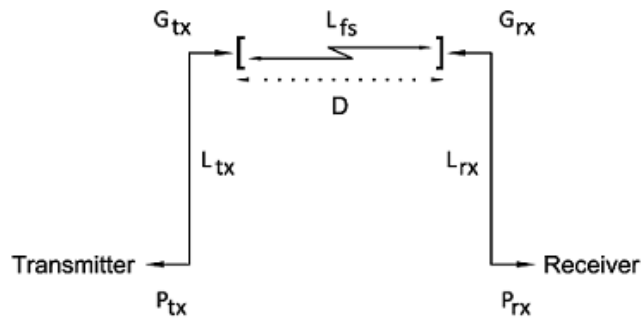


Fig 5.4. Link Budget parameters [66]

Receiver that installed has sensitivity (P_{RS}) from the manufacture's spec = 0.18 μ V for 12 dB called Signal-Including-Noise-And-Distortion or SINAD at 144 MHz. which can be converted dBm to dB μ V

$$P_{RS} = 20 \log_{10}(0.18) = -15 \text{ dB}\mu\text{V} \tag{1}$$

Then Convert dB μ V \rightarrow dBm in 50 Ω impedance by 107 dB subtraction:

$$P_{RS} = -14.9 - 107 = -122 \text{ dBm} \tag{2}$$

L_{FS} = free space loss or path loss in dB

$$L_{FS} = (4\pi d \div \lambda)^2 = (4\pi df \div c)^2 \quad (3)$$

λ = Wavelength (meter)

f = Frequency (Hz)

d = Distance between transmitter and receiver (meter)

c = Light speed in vacuum space 3×10^8

$$L_{FS} (dB) = 10 \log_{10} [(4\pi df \div c)^2] = 20 \log_{10}(4\pi df \div c) \quad (4)$$

$$L_{FS} (dB) = 20 \log_{10}(d) + 20 \log_{10}(f) - 147.55 \quad (5)$$

From Our Field-test found that result of this peer to peer communication in the maximum distance be able to achieve 19 Km (or 19,000 meters) on VHF frequency 144 MHz (or 144×10^6 Hz). Then enter this value to Equation (4) as below:

$$L_{FS} = 20 \log_{10}(19000) + 20 \log_{10}(144 \times 10^6) - 147.55 \quad (6)$$

$$L_{FS} = 99.21dB \quad (7)$$

P_{TX} = Transmitter output power = 36.98 dBm (5 Watts)

G_{TX} = Transmitter antenna gain = 2 dBi

L_{TX} = Transmitter losses = 1 dB

L_{FS} = Free space loss = 99.21dB

L_M = Miscellaneous losses = 3dB

G_{RX} = Receiver antenna gain = 0 dBi

L_{RX} = Receiver losses = 3 dB

D_{max} = 19 Km

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} \quad (8)$$

$$P_{RX} = 36.98 + 2 - 1 - 99.21 - 3 + 0 - 3 = -67.23 \text{ dB} \quad (9)$$

$$P_{RX} = -67.23 \text{ dBm} \quad (10)$$

The Link considered reliable reception when

$$P_{RX} > P_{RS} \quad (11)$$

Replace with the values from previous calculation

$$P_{RX} = -67.23 \text{ dBm} > P_{RS} = -122 \text{ dBm} \quad (12)$$

$$\text{Link Margin} = -122\text{dBm} - (-67.23\text{dBm}) = 54.77 \text{ dB} \quad (13)$$

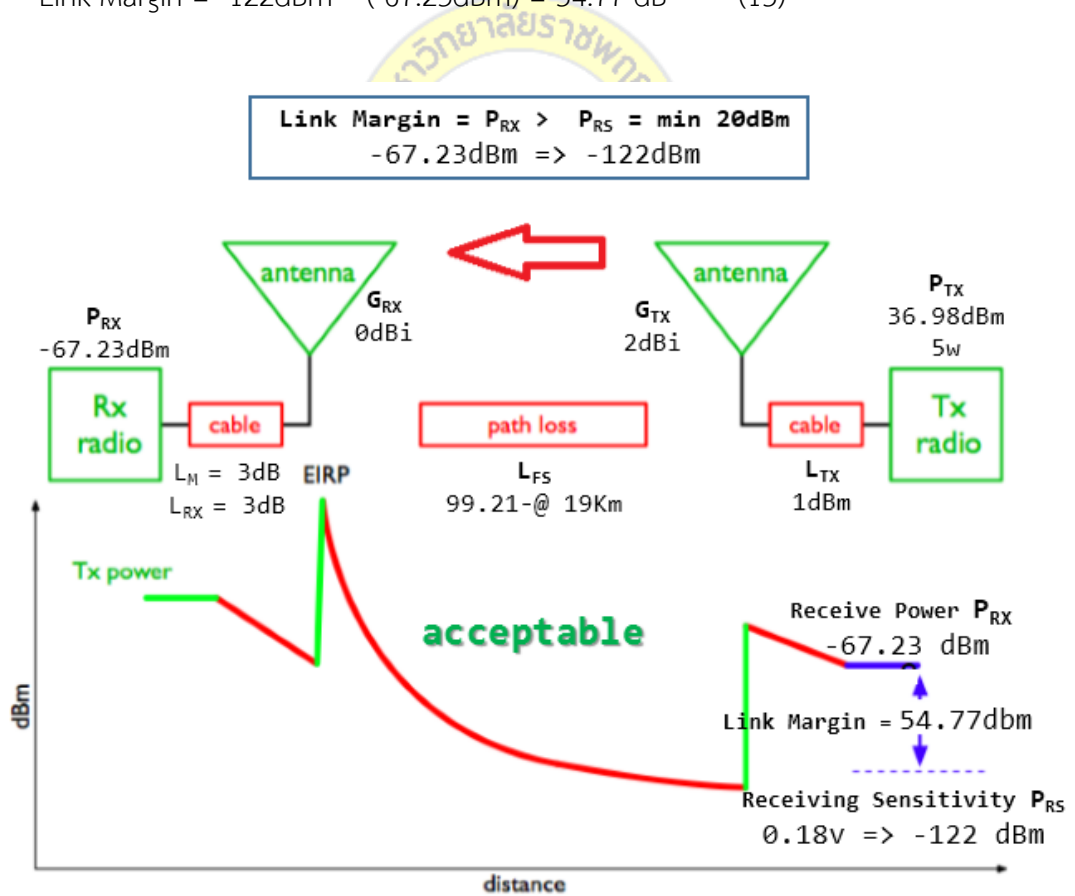


Fig. 5.5 Link Budget between TX and RX for Link Margin

This graph shown that we assumed that Link Margin of 20 dBm is the minimum value that set for validation on link for both peer can be acceptable, then can be concluded that the distance of (19,000 meters) mean to the maximum distance for this data communication with Link margin = **54.77 dBm**.

Table 5.1 Comparison from other method of protocol from Literature Review

| | GMRS | WIFI | APRS |
|-----------------------|-------------|---------------|------------|
| Function | Datalink | Datalink only | Customize |
| size (in) | 8 x11 | 3 x 6 | 2 x 3 |
| weight (g) | >1,000 | 600 | 200 |
| GPS Connection | Yes | No | Yes |
| Sensor Connection | No | No | Yes |
| Communcation Distance | Unlimited** | 200 feet | >10 Km *** |
| ราคารวม Cost (บาท) | 6,000 | 2,000 | <800 |

** As long as with in the cellular zone coverage

*** Depend on Antenna Propagation

5.5 Conclusion and Future research

The result of this research as this experiment 19 Km based on factor such as Antenna Gain, Transmit power and Antenna Propagation between both end which in the Line of sight (LOS) and this research will not limited for remote control but it can be used for Internet of Thing (IoT) will help to communicate as the sensor node from the rural area where no other internet network infrastructure but APRS will help to connect without any of infrastructure setup or based on low budget sensor node which need the long distance communication.

APRS protocol has been around the long time since 1986 which proven for this protocol that stable enough for the long distance communication with no infrastructure or any other protocol cannot be reached such as ground to Satellite more than 600 km and this research proven the concept that we can control Exploration Vehicle that very far away from Earth such as MARS. We can improve this communication range by install the digital repeater or using Low Earth Orbit Satellite

(LEO SAT) which can be store and forward method also in the International Space Station (ISS) which installed Radio Transceiver in digital mode using 145.825 MHz to help for extend data communication range.

Future work that would be suitable for this long range communication as the illegal logging protection or Alert system by using the Gyro-sensor at the tree when it has been disturb or cut down then Gyro-sensor included with accelerometer sensor will send the signal by using APRS protocol via Radio Frequency from the forest to the Internet Gateway network which connect to the WAN network and then alert to Authority by SMS or email.

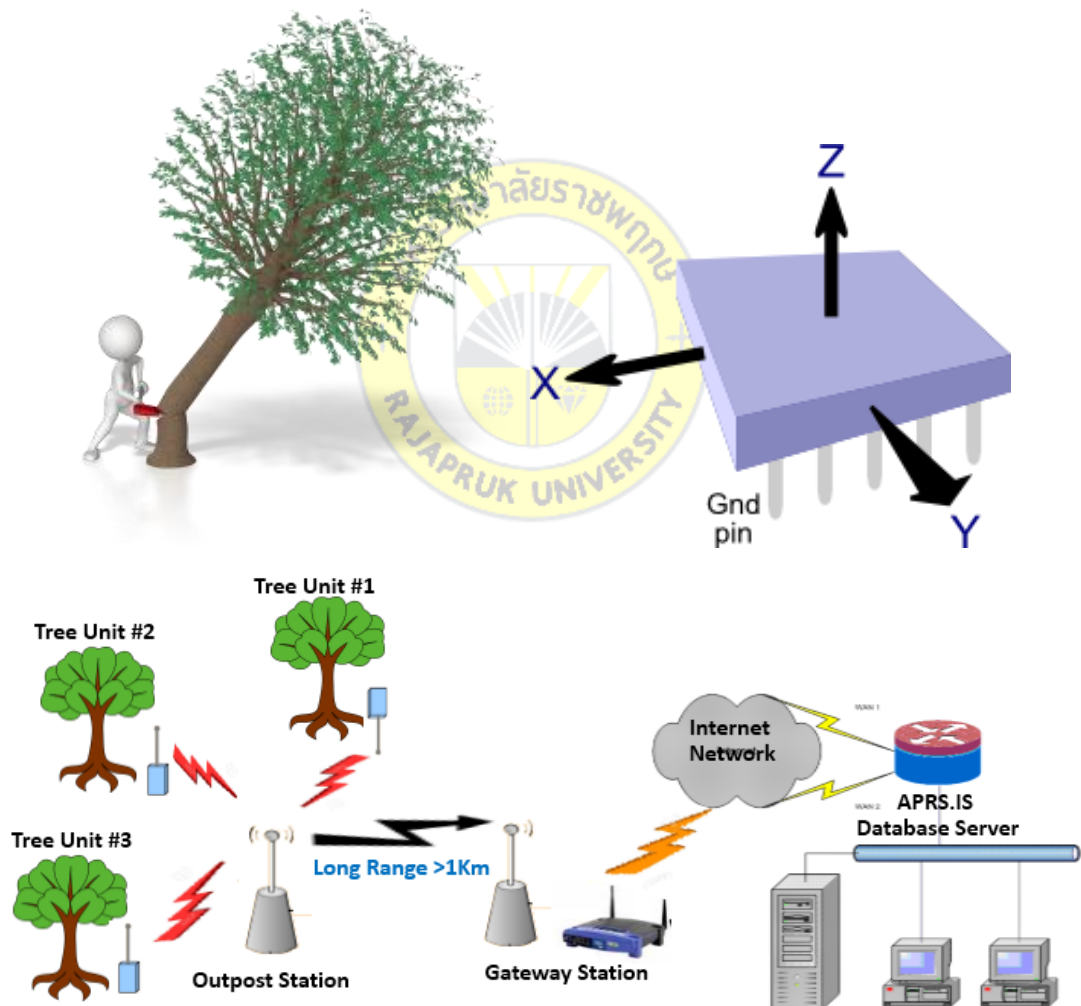


Fig. 5.6 Illegal Logging Protection System

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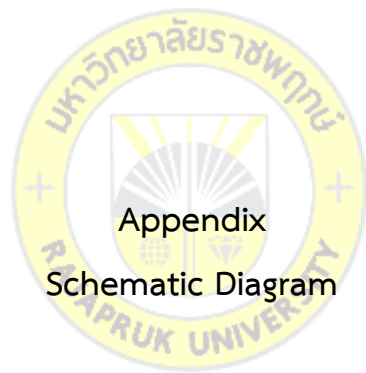
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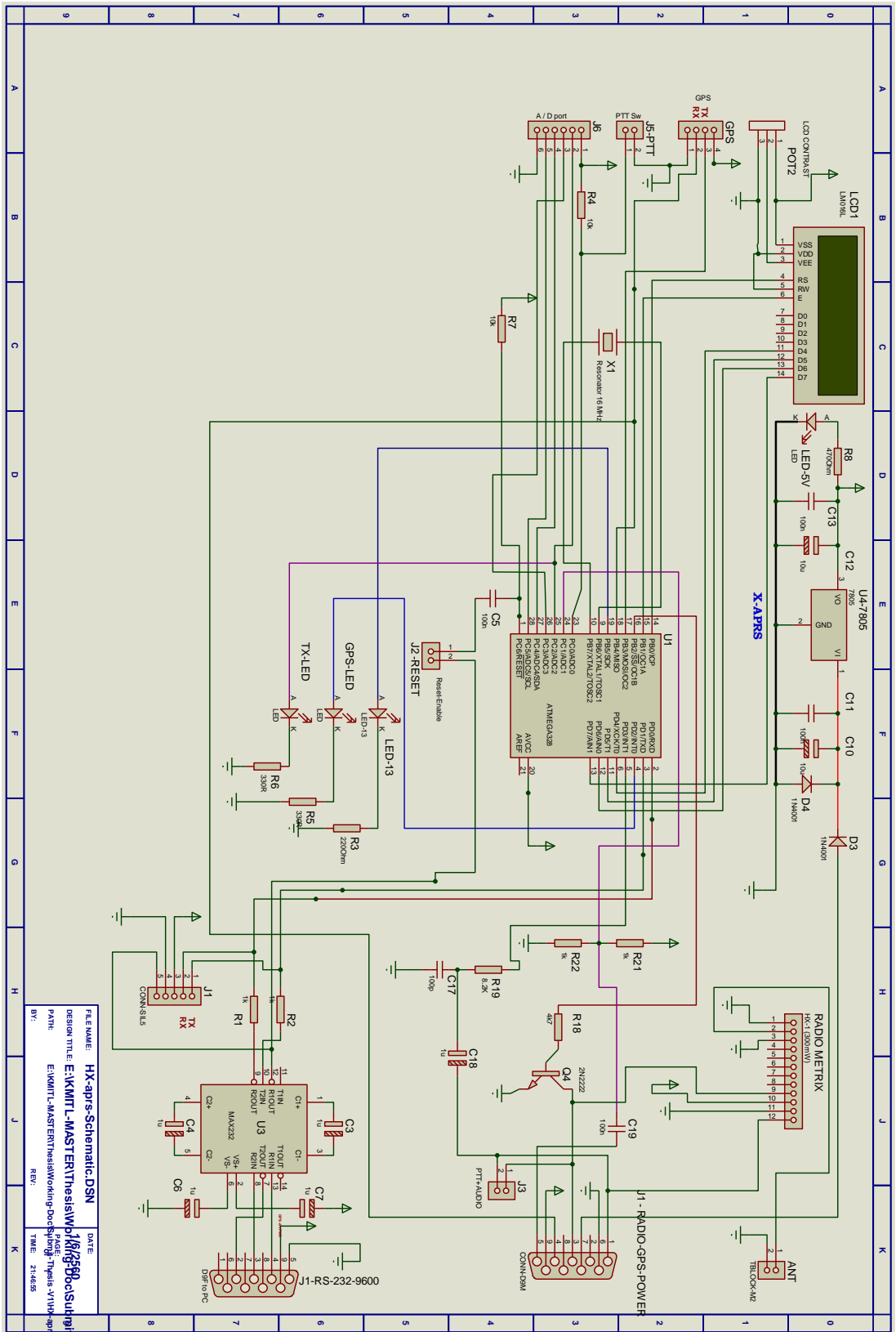
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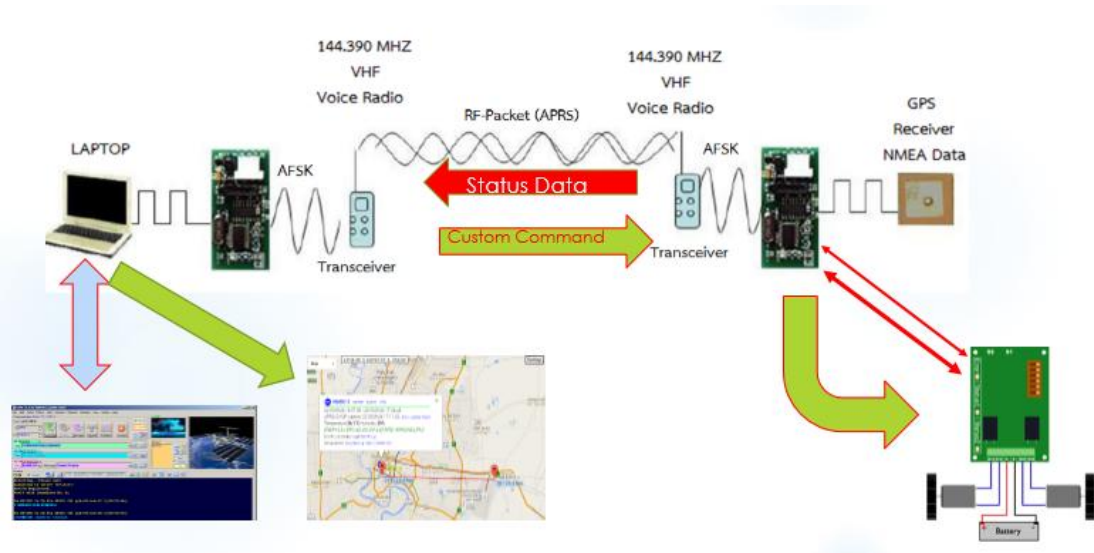
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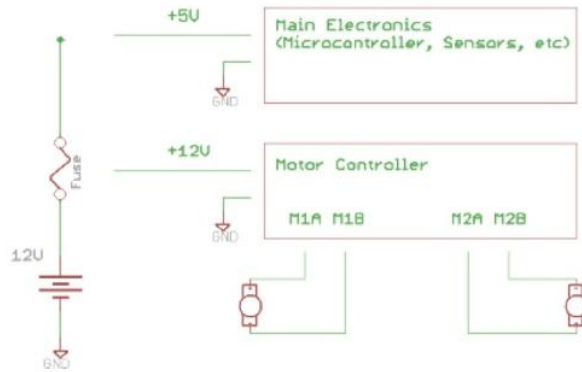
Appendix
Schematic Diagram



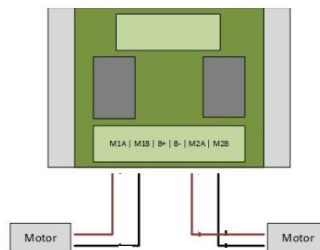
Visual Diagram



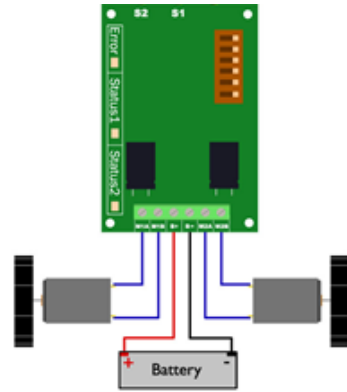
Wiring Diagram



Motor wiring Diagram



Testing Vehicle



Power Consumption data collection Bench Test



| @12VDC | Beacon unit |
|-----------------------|-------------|
| Standby | 230mA |
| Transmissing test #1 | 452mA |
| Transmissing test #2 | 455mA |
| Transmissing test #3 | 421mA |
| Transmissing test #4 | 410mA |
| Transmissing test #5 | 418mA |
| StandBy power (watts) | 2.7 |
| Avg TX Power (watts) | 5.17 |

Note: The value of the current is slightly changed during the test period, because GPS has some effect on pulling current from time to time. Technically, there should not be much change.

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Biography

| | |
|-------------------------|---|
| Name | Mr. Nimit Hongyim |
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| Education | 2017 Master Computer Engineer, King Mongkut Institute of Technology Ladkrabang 2016 Master Business Administrator, Kasetsart University 1996 Bachelor Computer Engineering, King Mongkut Institute of Technology Ladkrabang |
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| Work | |
| 2013 – Present | Managing Director Sinolux International (Thailand) Co., Ltd. Dragon Guard Intergroup Security Guard Co.,Ltd. |
| 2016 – Present | Lectuer, Business Computer, Rajapruk University |
| 2015 – Present | Researcher for ITAP program (NSTDA) |
| 2013 - 2015 | Sr. Operation Director, Star Microelectronic PLC. |
| 2001 - 2013 | Engineering Management for Catalyst Buseiness Unit of ON semiconductor Corp. Santa Clara, California, USA. |

Research Paper

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5. "Microcontroller Based for Smart Mushroom Cropping"* ECTI-CARD #8 2016, Hua Hin, Thailand, 27-29 July 2016 (*Best Paper Award*)*
6. "The Grow Rate tracking System of the tree for Forest Industry" The International Conference on Intelligent Systems and Image Processing 2016 (ICISIP 2016)

