DESIGN AND ANALYSIS OF LOW SPEED DIGITAL TRANSCEIVER CIRCUIT THROUGH RADIO FREQUENCY (VHF BAND)

By

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Department of Electrical and Electronics Engineering
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Approved,

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Mr Azman bin Zakariya
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2014

CERTIFICATION OF ORIGINALITY

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

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(MAZIAH BINTI MUHAMAD NORDIN)

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Lastly, thanks again for unlimited contribution towards to all people around me and my sincere apologies for any inconveniences and problems caused throughout my research for completion this Final Year Project.

ABSTRACT

The rapid growth of technology has drastically changed the communications technology. To meet the present day technology needs, data transfers at higher speeds are to be achieved which is possible by Radio Frequency (RF) communication. Transmission through Radio Frequency is another option of wireless communication that utilizes effective radio frequency, other than hand phone and Internet resource. Communication through radio is unique and has its own extras.

Hence this project intends to design low speed digital tranceiver circuit trough RF, user can send the texts, folder and graphic to user that has same equipment in another station depending on the transceiver. Besides, it is also possible to transmit a voice with the use of handy talkie. This project is important especially when it comes to lack of telecommunication signal, like no Internet connection, outside Bluetooth range, no coverage for mobile phone or when travelling in the mountain and forest where there are places that don't have a facility for communication.

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List of Abbreviations

Abbv	Definitions
ADC	Analogue to Digital Converter
AM	Amplitude Modulation
CRT	Cathode Ray Tube
DAC	Digital to Analogue Converter
FM	Frequency Modulation
HF	High Frequencies
PSNR	Peak Signal to Noise Ratio
PSK	Phase Shift Keying
RF	Radio Frequencies
SDR	Software Define Radio
SIMO	Single Input Multiple Outputs
SNR	Signal to Noise Ratio
SPHIT	Set Partitioning in Hierarchical Trees
SSTV	Slow Scan Television
UHF	Ultrahigh Frequency
VHF	Very High Frequency
USB	Universal Serial Bus
USRP	Universal Software Radio Peripheral

CHAPTER 1: INTRODUCTION

There are many ways to communicate data that are wireless or wired. This Project describes a design of effective data communication without wires and the medium of communication is air by using radio frequencies. It is a form of digital data transmission used to link computers.

This communications is a computer telecommunications using VHF (Very High Frequency). It is similar with the communication via telephone. The telephone modem is replaced by a soundcard (act as modem), the telephone is replaced by a transceiver (hand held), and the phone system is replaced by the free waves (144Mhz- 148MHz). The data sent from a computer and transmit via radio to another radio station similarly equipped.

By using SIMO (Single Input Multiple Outputs) transmission mode, the image can be transmit from an input and receive by many receiver shown in figure 1.

Figure 1: The transmission mode of SIMO (single input multiple outputs)

1.1 Project Background

Bluetooth wireless communication technology is widely used to exchanging data over short distance. It is used in many applications such as headset and speaker but this technology also has the disadvantages such only connect in limited range and heavy drain on battery life. It is easy to get simple transmission like Internet connection. During emergency/disaster there is a vital requirement for wireless communication with sufficient distance of coverage. It can provide emergency communications when everything else is down using VHF or UHF frequency band.

1.2 Problem Statement

This project is to develop a long-range wireless transmission using low frequency transmission (VHF band). This project aims to counter Bluetooth problem by developing a PSK (phase shift Keying modulator) and transceiver circuit design in VHF band. It should be able to overcome the problem of limited range and operate at lower power transmission. This project is useful for providing telecommunication signal during natural disaster such earthquakes or rural area because it not depends on local antenna.

1.3 Objective and Scope of Study

1.3.1 Objective

The objective of this project to design a wireless image transmissions using Radio Frequency (RF) technology with the following features:

1. To extract the significant features of wireless transmission using radio frequency (VHF).
2. To design and analysis the digital PSK modulator circuit design.
3. To integrate communication interfacing to VHF transceiver circuit for transmitting image data.

1.3.2 Scope of Study

This project will be divided into several stages. First the Phase-shift keying (PSK) interface will be designed to act as the brains for the system, Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). Futhermore this project only used Very High Frequency (VHF), which the range of the transmission is limited.

1.4 Relevancy Of The Project

By carrying out this project, the development of wireless image transmission using low frequency transmission (VHF band) will be able to become a more widely used in communication technology as emergency communicators.

1.5 Feasibility of The Project

Within the 8 months (FYP 1 & FYP 2) and the limited budget given for this project, it is expected that a prototype of a low speed digital transceiver Circuit Through Radio Frequency (UHF band) will be able to be completed.

CHAPTER 2: LITERATURE REVIEW & THEORETICAL BACKGROUND

2.1 Literature Review

Daniel Grobe et. Al. (2000) proposed a wireless image transmission using multiple-description based concatenated codes by the SPIHT image coder. Set partitioning in hierarchical trees (SPHIT) [2] is a image compression algorithm that exploits the inherent similarities across the sub band in wavelet decomposition of an image.The disadvantages of this SPHIT image coder is highly sensitive to errors and the error-correction code is used to concatenated channel code including a row (outer) code based on RCPC codes with CRC error detection and a source-channel column (inner) code consisting of the scalable SPIHT image coder [1].

In another research [3], the authors proposed a wireless transmission of JPEG file using GNU Radio and USRP. Universal Software Radio Peripheral (USRP) is the hardware device, which is flexible enough to integrate with GNU radio act like an open source toolkit by implementing Software Defined Radio functionalities to make radio hardware independent [3].

According to [3], there are some research of wireless transmission application development based on GNU Radio and USRP, basically this implementation concentrated mainly on the modulation/demodulation scheme rather than wireless communications and the disadvantages in implementing wireless transmission are long header resulting in larger overhead and also the compatibility of Python versions.

Figure 2 explains about the process of how GNU radio and USRP transmit the JPEG. GNU radio built with C++ programming as a various signal processing function that done by Python and as mentioned above USRP is the hardware platform for SDR which is composed of FPGA, ADC/DAC and USB controller [3]. ADC/DAC is to converts the data from analog to digital format and vice-versa and USB is used to transfer data from USRP to host computer for signal processing.

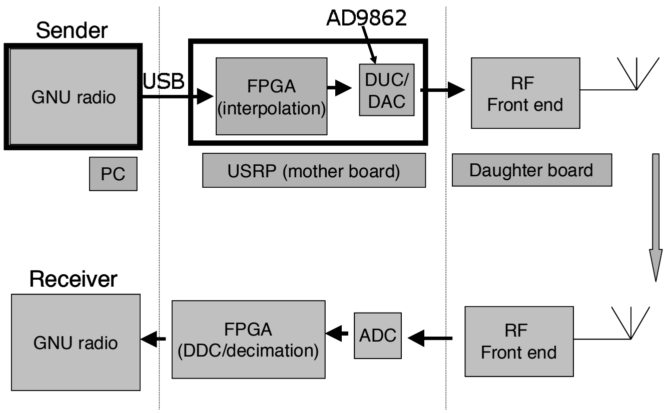


Figure 2: Software Radio Architecture [3]

In [5], the authors showed a cross layer approach to wireless image transmission over a Rayleigh fading channels to compared the relationship between the channel SNR and Peak SNR (PSNR) of the received image in three conditions with multiple thresholds, with a single threshold of 0.8 and without the selective approach and the performance results also shown in this research paper. For example, with SNR = 5dB and BPSK modulation in a Rayleigh flat fading channel, the PSNR of the received image with the proposed approach has a gain of 7dB over the previous solution [4]. The images were chosen for transmission based on the SNR and their importance in the image by consideration of a cross layer design and selective approach for wireless image transmission [5].

2.2 Theoretical Background

2.2.1 Digital Image Processing

Many of the techniques of image processing were developed in order to process the image. The techniques that recently used are analogue image processing and digital image processing. Figure 3 shows a concept of digital image processing, a digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels [11].

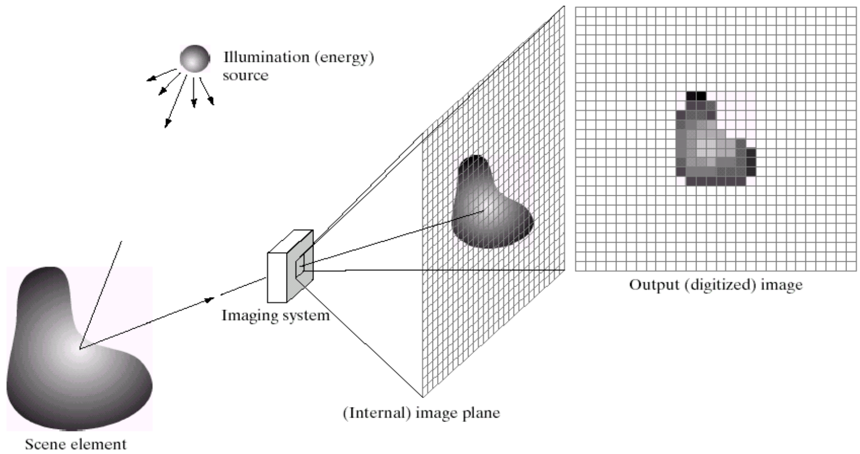


Figure 3: Digital Image Processing concept [11]

Many advantage of digital image processing over the analogue image processing. Digital image processing allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing [10]. Digital image processing focuses on two major tasks [11]:

1. Improvement of pictorial information for human interpretation
2. Processing of image data for storage, transmission and representation for autonomous machine perception

2.2.2 Brief History of Digital Image Processing

Digital image processing began as digital computers were pressed into scientific applications such as space exploration, military applications, industrial robotics, medical imaging, and many other fields soon provided both the needs and the funding to develop digital image processing hardware and algorithms [11]. Many other schools and corporations developed digital image processing systems and most of these systems were designed for medium to high image resolution (256 X 256 to 2048 X 2048) and have to be used with a mainframe computer or at least a large minicomputer with the systems were, therefore, quite expensive, with costs starting around $40,000 [7].

One of the first efforts to make a low cost digital image processing system was published by [8] describing a mini computer based system with a resolution of 320 x 250 x 6.

2.3 Software and Implementation

2.3.1 History of SSTV

In [8], the authors mentioned that a way to transmit a television image using less than 3KHz bandwidth on amateur radio (ham) frequencies and he designed an amplitude modulated (AM) system that required 8 seconds to transmit one frame of an image at reduced spatial resolution, after that he started a new mode of amateur communication, slow scan television (SSTV). In two published articles, he described a flying spot slide scanner and a receiving monitor that used a radar CRT with a very long persistence phosphor [8].

2.3.2 Slow Scan Television (SSTV)

Slow Scan Televsion or known as SSTV, is the graphic mode in which user can exchange the pictures over the radio. SSTV is a means to pass still photos or other pictures over the air. SSTV is sent in both analog and digital modes. In [13] analogue SSTV, the different audio tones are used to make the different colors in the SSTV picture and the black video corresponds to an audio tone of 1500 Hz while white is sent at 2300 Hz. Therefore, grey is sent anywhere between these two frequencies, and color images are sent by sequentially sending the red, green, & blue pulses, depending on the SSTV mode used.

Figure 4 explained about the SSTV trasmission block diagram, which the 2MHz crystal controlled clock signal from the CPU board is cleaned up, then goes to the clock input of both counters and the pixel clock divider is initialized to divide by 959 to provide the pixel clock frequency of 2085Hz [13]. On the other hand, the CPU with an input statement can test each rising edge of the pixel clock sets of the sample time latch. If the program is setting to clears the latch and sends the proper divisor value to the pixel frequency divider, the divisor value is taken from a table by the SSTV transmit program to correspond to the proper pixel value or sync [13].

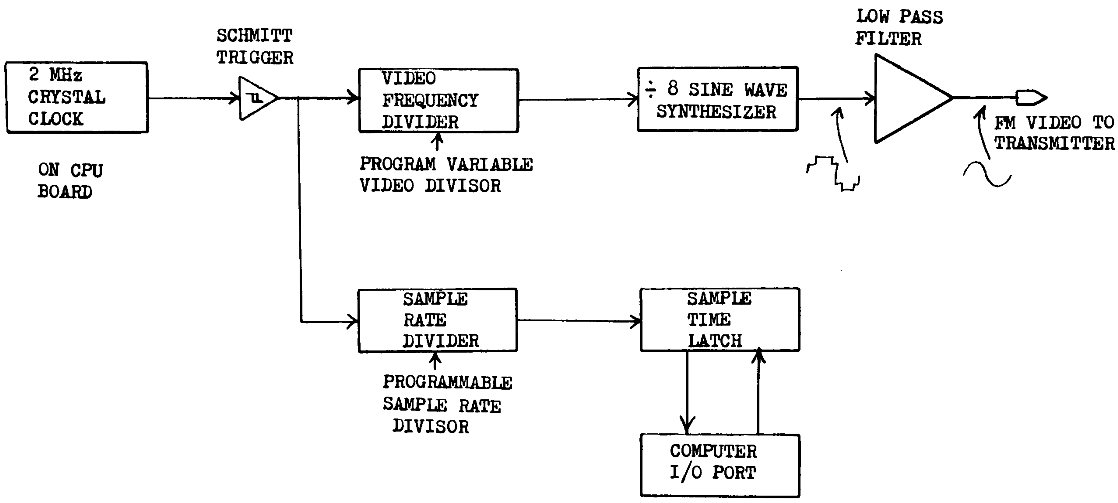


Figure 4: SSTV Transmit Block Diagram [13]

2.4 Design and Implementation

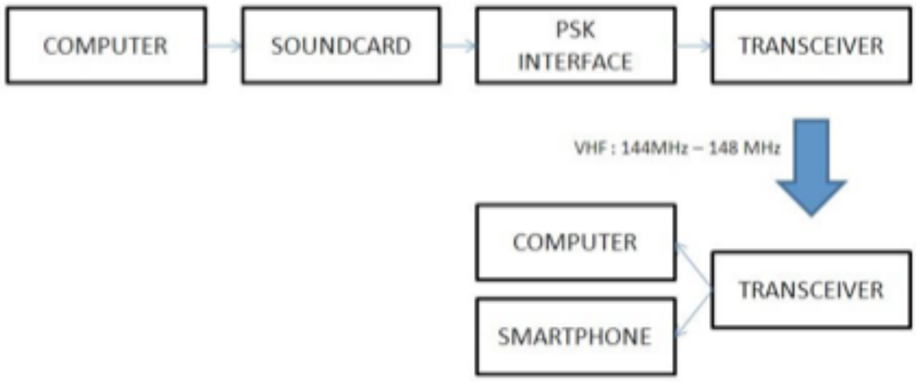


Figure 5: Project Block Diagram

This project consists of a terminal or the computer as the main I0 peripheral, a soundcard, which act as a modem, a PSK interface and also a transceiver with an antenna shown in figure 5. The built-in soundcard in the terminal either in a computer or a laptop will later process all the data into a coded signal, ready for transmission and through the terminal, user can display the items or files they want to send such as graphic files, text files or folders.

In this project, the soundcard act as modem which any data it receives from the terminal in the form of digital signals will be modulated into an analog signal form. For personal computers or PC these ports are called serial or COM ports.

The PSK interface circuit was used as an interface between the transceiver and the terminal. The output of the receiver was directly connected to the input of the sound card through the PSK interface. When the user types or selects the graphic that is ready to be send, the computer or the terminal will display the data and the data will automatically be sent through the circuit from the transceiver to another station through radio wave (RF). All PSK related software could implement by this project.

2.4.1 Digital Modulation - Phase-shift keying (PSK)

There are three major classes of digital modulation techniques used for transmission of digitally represented data:

i. Amplitude-shift keying (ASK)
ii. Frequency-shift keying (FSK)
iii. Phase-shift keying (PSK)

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing or modulating the phase of a reference signal (the carrier wave) and any digital modulation scheme uses a finite number of distinct signals to represent digital data [12] shown in figure 6.

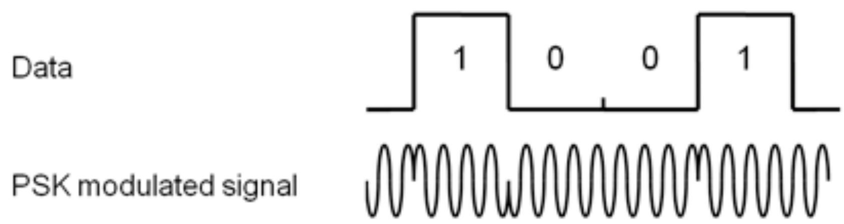


Figure 6: Phase Shift Keying (PSK)

Thus, each phase encodes an equal number of bits and each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data [14].

2.4.2 Soundcard

A sound card is an internal computer expansion card that facilitates the input and output of audio signals to and from a computer under control of computer programs. The term sound card is also applied to external audio interfaces that use software to generate sound, as opposed to using hardware inside the PC. Example of souncard shown in figure 7 is typical uses of sound cards include providing the audio component for multimedia applications such as music composition, editing video or audio, presentation, education and entertainment (games) and video projection.

Figure 7: Example of a Soundcard that used in CPU

2.4.3 Transceiver communication

A transceiver is a device that consists of both transmitter and a receiver. It function as a transmitter of the data and also described as a receiver of the data that combined and shared common circuitry in a single housing, but when both are no between the function circuitry, the device is a transmitter-receiver.

Figure 8: Transceiver

Handheld radios contain all the necessary equipment for radio communications with another station. A typical radio used as a handheld station integrates a transceiver with an antenna and a battery in one handheld package. Handheld transceivers used in this project shown in figure 8 are designed for operation on the VHF amateur radio bands and most often are capable of only FM voice communications transmissions. To conserve battery power, they have limited transmitter power, typically below lW, to cover a local range of typically a few miles.

The VHF (very high frequency) range of the radio spectrum is the band extending from 30MHz to 300 MHz shows in table 1 the band of frequency range. The wavelengths corresponding to these limit frequencies are 10 meters and 1 meter. The VHF band is popular for mobile two-way radio communication. A great deal of satellite communication and broadcasting is done at VHF.

Table 1: The band of frequency range.

Band	Frequency range	Wavelength range
Extremely low frequency (ELF)	< 3 kHz	>100 km
Very low frequency (VLF)	3 - 30 Hz	10 - 100 krn
Low frequency(LF)	30 - 300 kHz	1 - 10 km
Medium frequency (MF)	300 kHz - 3 MHz	100m - 1km
High frequency (HF)	3 - 30 MHz	10 - 100m
Very high frequency (VHF)	30 - 300 MHz	1 - 10m
Ultra high frequency (UHF)	300 MHz - 3 GHz	10cm - 1m
Super high frequency (SHF)	3 - 30 GHz	1 - 10cm
Extremely high frequency (EHF)	30 - 300 GHz	1mm - 1cm

2.4.4 Basic Types of Antennas

There are two basic types of antennas most commonly used applications are omni-directional and directional (point-to-point). Omni-directional antennas shows in figure 9 are the easiest to use and the most common. As the name suggests, the omni-directional antenna does not require aiming. The electromagnetic energy from the antenna radiates in all directions but typically is strongest perpendicular to the body of the antenna. Omni directional antennas are often used indoors and when the needed range is usually tens of metres.

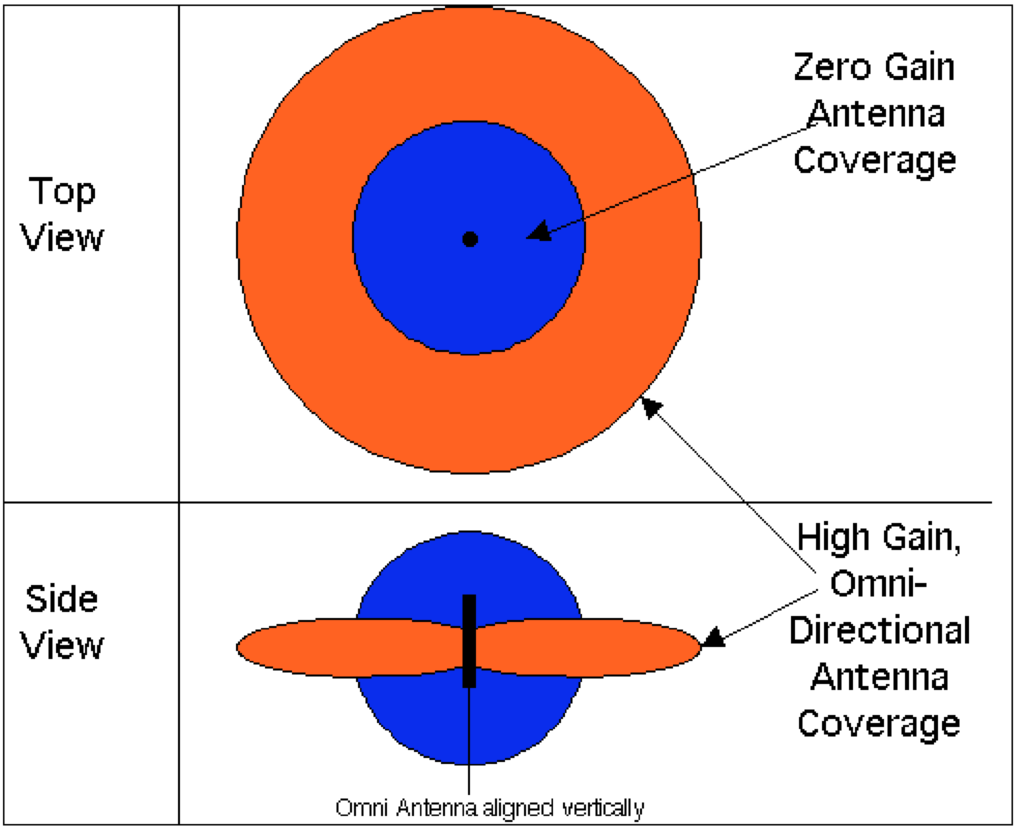


Figure 9: The Coverage Of Omnidirectional Antenna

CHAPTER 3: METHODOLOGY

This chapter will explain about the method has been taken in order to reach the objectives of the project and a closer look on how the project is implemented. Each selection and achievement taken when the project is implemented will be explained in detail for each stage until the project is success.

3.1 Research Methodology

This project, involve software and hardware. The method that is used is suitable circuit and suitable component for the circuit, construction and finally testing the circuit and combined the software. For the aforementioned objectives to be successfully achieved, the project is classified into three phases, namely:

- Research & PSK Interface Design (Phase 1)
- Hardware Development and Improvement (Phase 2)
- Implementation PSK Interface with SSTV Software (Phase 3)

For the research phase, brief research and literature review is done by reading and understanding the research papers and reference books that concentrate on the SSTV Software application development including PSK Interface design which is the interfacing circuit between transceiver, receiver and SSTV Software. The relevancy of the technical papers towards project objectives is put into account to increase the credibility of this project. The source code and brief research regarding the SSTV Software application and interfacing development are carried out on several resources such as books and through the research on internet.

3.2 Hardware Development and Improvement

In order to develop this final year project, PSK interface is the hardware implementation for this project. The interface indicates the data by transmitting and receiving the image. In software implementation, the MMSSTV software (Graphic mode) was applied by using digital mode and the image mode, which used for the graphical, figure and map transmission. The software used for smartphone is SSTV - Black Cat System, which it is design as a transceiver and receiver.

During the completion of this prototype, a few problem occurred. To solve it troubleshotting and testing has been done Figure 10 and figure 11 is the schematic and circuit of PSK Interface that have been built. In the first attempt, this PSK Interface circuit failed to control the push to talk button.

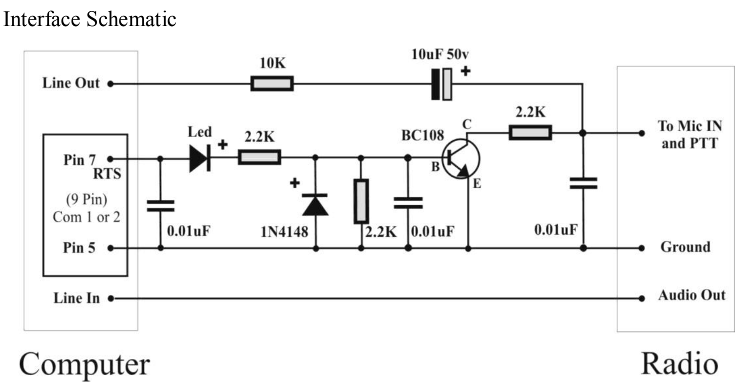


Figure 10: PSK Interface 1 Schematic

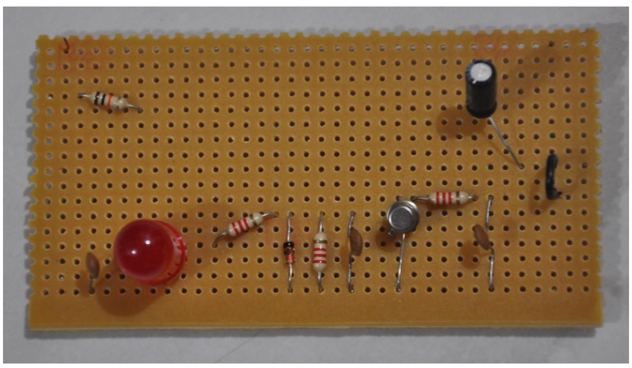


Figure 11: PSK Interface 1 Circuit – Failed

3.3 Implementation PSK Interface with SSTV Software

The implementation of suitable circuit with the software is will test and the result has been recorded in Chapter 4. This interface also works for SSTV, RTTY and DigiPan and this interface with the Icom IC-V8 (Transceiver). The interface requires no external power and is operated by the computer's serial port. This project consists of a terminal or the computer as the main I0 peripheral, a soundcard which act as a modem, a PSK interface and also a transceiver with an antenna.

The built-in soundcard in the terminal either in a computer or a laptop (8 bits type) will later process all the data into a coded signal, ready for transmission and through the terminal, user can display the items or files they want to send such as graphic files, text files or folders. In this project, the soundcard act as modem which any data it receives from the terminal in the form of digital signals will be modulated into an analog signal form. For personal computers or PC these ports are called serial or COM ports.

The PSK interface circuit was used as an interface between the transceiver and the terminal. The output of the receiver was directly connected to the input of the sound card through the PSK interface. When the user types or selects the graphic that is ready to be send, the computer or the terminal will display the data and the data will automatically be sent through the circuit from the transceiver to another station through radio wave (RF). All PSK related software could implement by this project.

3.3.1 Installation and Implementation of SSTV

Installing of SSTV requires several steps.

1. Download and installed SSTV Software at http://www.qsl.net/mmhamsoft/mmsstv. There are several version of the SSTV Software and the latest version is recommended. For Apple laptops or PC, the download and installed SSTV Software at http://www.blackcatsystems.com/software/multimode.html. This SSTV software is more easier and compitable with windows server. It is a self-extracting (executable) file, so just click and follow the prompts.

2. Give a location from the PC to store the workspace. Workspace is the location or the folder to keep all the image or data that create for the SSTV application as per figure 12.

Figure 12: SSTV Software at the PC or Computer

3. Download and install SSTV Software for smartphone (used Apple’s smartphone) at https://itunes.apple.com/us/app/sstv/id387910013?mt=8 . Figure 13 shows the interface of SSTV at the smartphone.

Figure 13: SSTV - Black Cat System for Smartphone

4. Open MMSSTV.On the tool bar, click on '**OPTION**' then '**MMSSTV Setup**'. Click on the '**RX**' tab and check '**Auto Stop**', '**Auto Restart**', '**Auto Resync**' and '**Auto Slant**'. (If have a slower computer, or limited RAM, may be better off leaving Auto Slant off). Then click on 'OK' to save settings and return to the main screen.

5. Under 'RX Mode' '**Auto**' should be on. Tune to 14230.0 USB, sit back and watch it all happen. If you leave, when you come back click on the 'History' tab and you can review pictures received while you were away.

3.4 Flow Chart

Figure 14 is a flow chart that explains the methodology in executing the project.

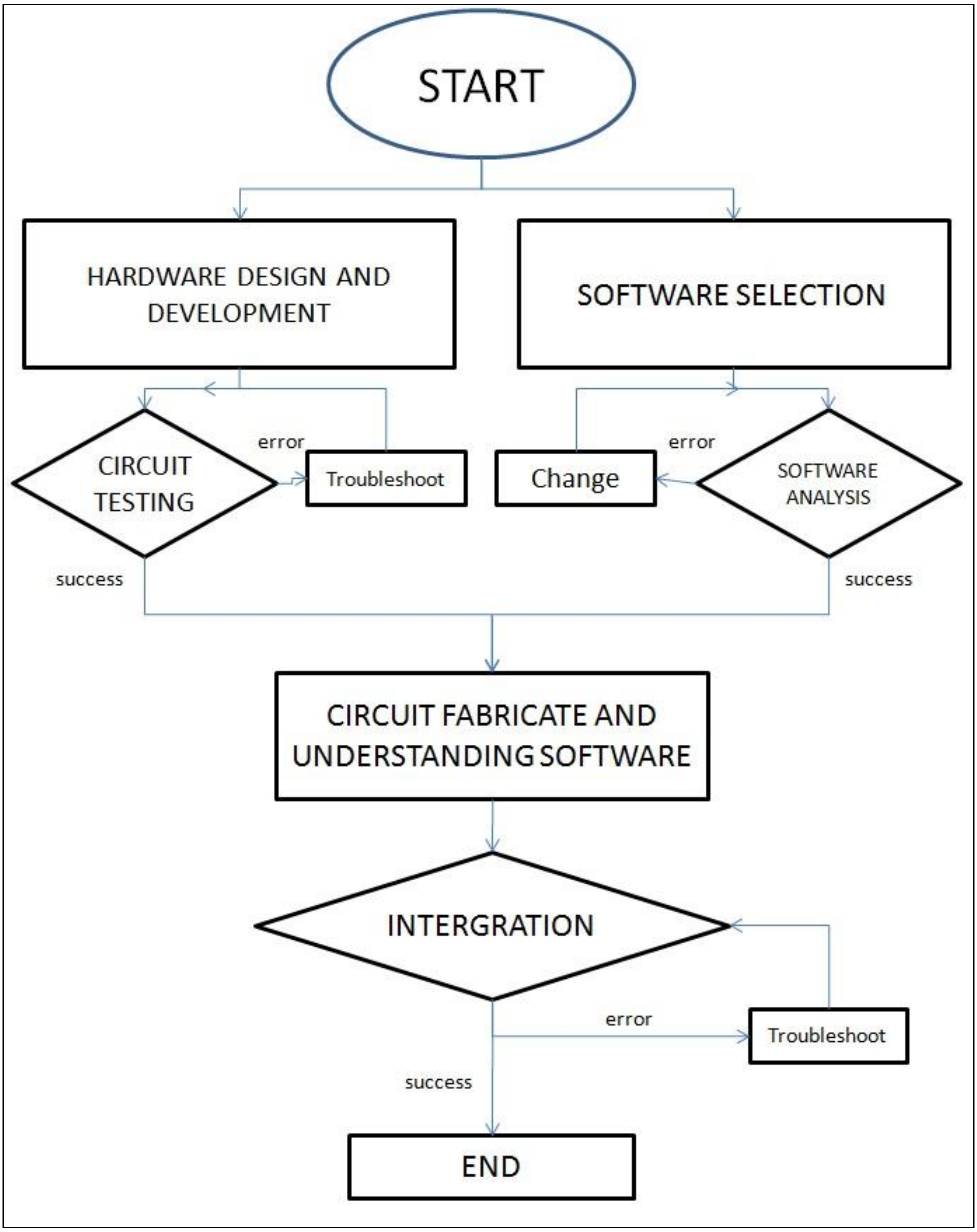


Figure 14: Project Methodology in a flow chart

The start of each project needs its strategy in the planning and application. In this project first, the application is identified. As soon as the purpose and function of the project is clear, the project will be divided into two parts shown in figure 14.

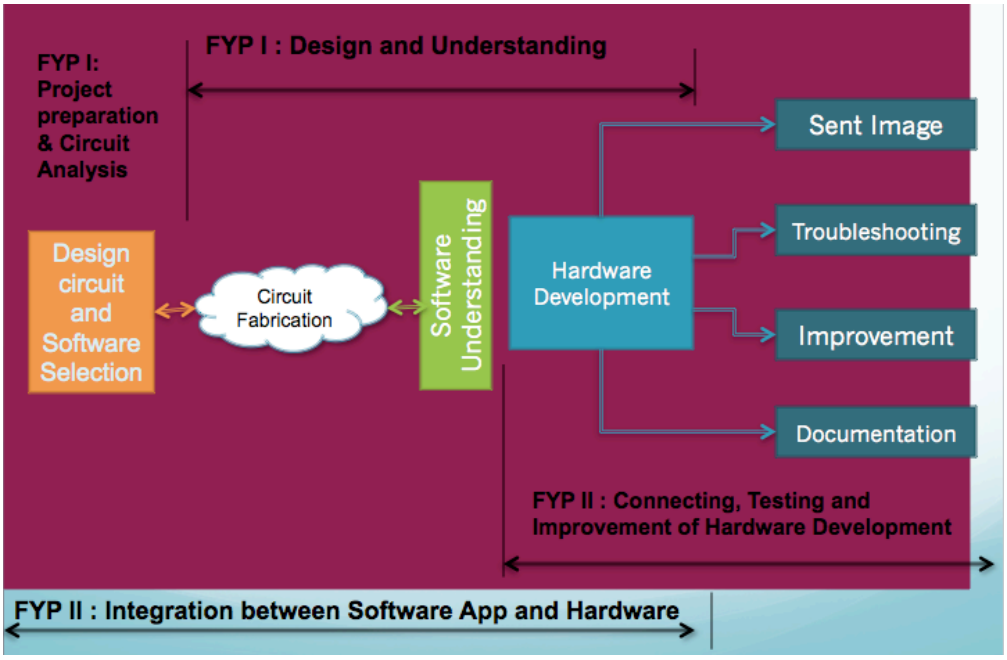


Figure 15: Project Planning

Based on figure 15, first part is hardware design and development. For the hardware design, initially the design has to be built. The circuit must be tested first to check if any problems and do some simulation. If the simulations meet an error, the circuit have to be troubleshoots to recognize the problem. The second part is software selection. The software that been used are the MMSSTV and it was designed to programmed the transmission.

The overall program is separated into small partitions because it is easier to troubleshoot. If the hardware design and the software development have no errors and counter no problem the merging of the hardware design and software development will be done. The combination of both, will be tested, simulated and troubleshoot. In the process of troubleshooting, the project will be analyzed and repaired. As the integrations are successes, the project can run smoothly without facing any technical problem.

3.5 Gantt Chart and Milestone Planning

The time frame allocated for this research study is 8 months which is start from June 2013 for final year project I and will be continue on final year project II which is on September 2013 to complete the prototype and testing. The Gantt chart and milestone planning is shown in table 4 below.

Table 2: Gantt chart and Milestone Planning

Final Year Project I & II Gantt Chart															
No	Activities	Weeks													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	FYP 1 Progress and Milestone **(May 2013)**														
1	Title selection														
2	Preliminary Research & Literature Review														
3	Components Identification														
4	Prototype preparation (Purchasing components, PSK modulator circuit, Basic Interconnection)														
5	Familiarize with SSTV Software Interfacing														
6	Circuit Analysis in P-Spice														
	FYP 1 Assessment														
1	Extended Proposal														
2	Proposal Defense														
3	FYP1 Report (Draft Interim)														
4	FYP1 Report (Final Interim)														
	FYP II Progress and Milestone **(September 2013)**														
1	Fabricate PSK modulator circuit, Testing and Measurement.														
2	Integration of All Subcomponents														
3	Troubleshooting and Improvement														
4	Complete Prototype Development														
5	Testing and Measurement														
6	Report / Thesis														

<u>Final Year Project I Milestone.</u>

- Title selection : Week 1
- Preliminary research & literature review : Week 2
- Component Identification : Week 4
- Prototype Preparations : Week 8
- Software familiarize and circuit analysis : Week 8

<u>Final Year Project II Milestone.</u>

- Fabrication of PSK Modulator Circuit : Week 1
- Integrations of All Subcomponents : Week 2
- Troubleshoot and Improvement : Week 4
- Completing Prototype Development : Week 7
- Testing and Measurement : Week 3

3.6 Tools

3.6.1 Hardware

1. Transceiver Module & Soundcard
2. PSK Interface (PCB Fabrication)

3.6.2 Software

1. MMSSTV Software – Transmission Software
2. Aqilent ADS software
3. MATLAB® – Analysis Software
4. Pspice – Circuit Design

CHAPTER 4: RESULT AND DISCUSSION

4. Final Year Project II Development

This chapter will discuss the result obtained related to the project in the final year semester. At the same time, this chapter analyzes the information related to the result and development of this project. Furthermore, this chapter also elaborate how the result produced for this development of image transmission using radio frequency. The result may consist of hardware and software development for this project as shown in figure 16.

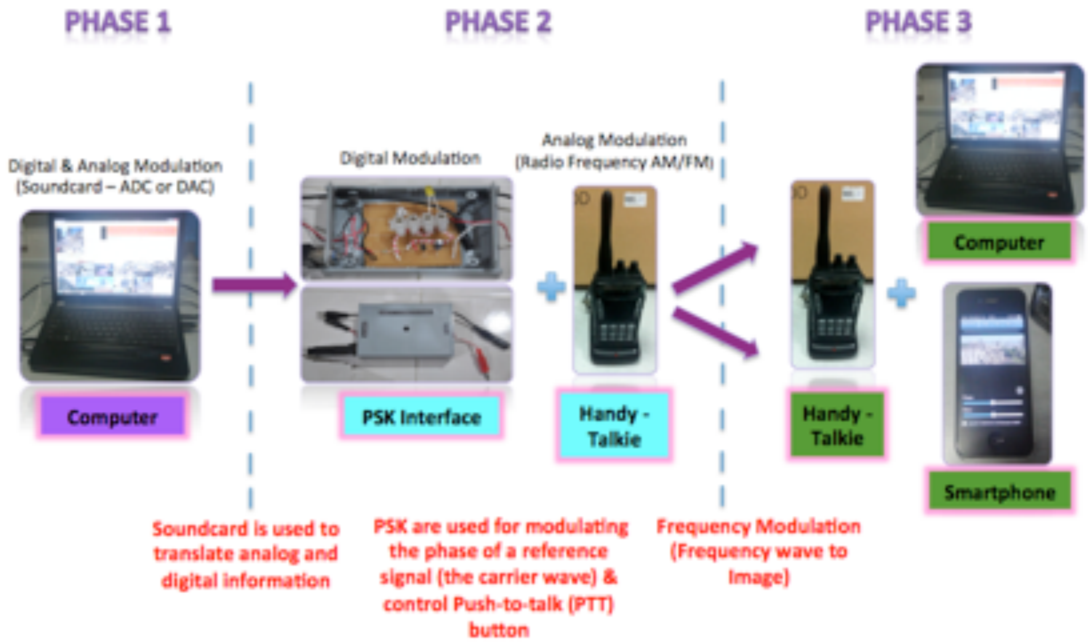


Figure 16: Complete Project Design

4.1 Software Implementation Result - Phase 1

In the phase 1 for the software development, the Slow-scan television (SSTV) Software was selected as image transmission method to transmit and receive static pictures via handy talkie in monochrome or color. The software used the computer's soundcard to generate the SSTV audio tone, which is fed into the microphone input of a transceiver. It also used the soundcard to decode the incoming signal.

4.1.1 SSTV Software

SSTV is a narrow-band mode, which means that signals in this mode can be transmitted on normal voice channels, thus the voice can reach with SSTV signals in appropriate bands [17]. The SSTV software has the capability to send & receive various different modes. SSTV uses analogue frequency modulation in which every different value of brightness in the image gets a different audio frequency. In other words, the signal frequency shifts up or down to designate brighter or darker pixels, respectively. Color is achieved by sending the brightness of each color component (usually red, green and blue) separately. Figure 17 shows the interface of SSTV Software, which consists TX Mode, scan line, sending image, RX and others toolbar menu at the interface.

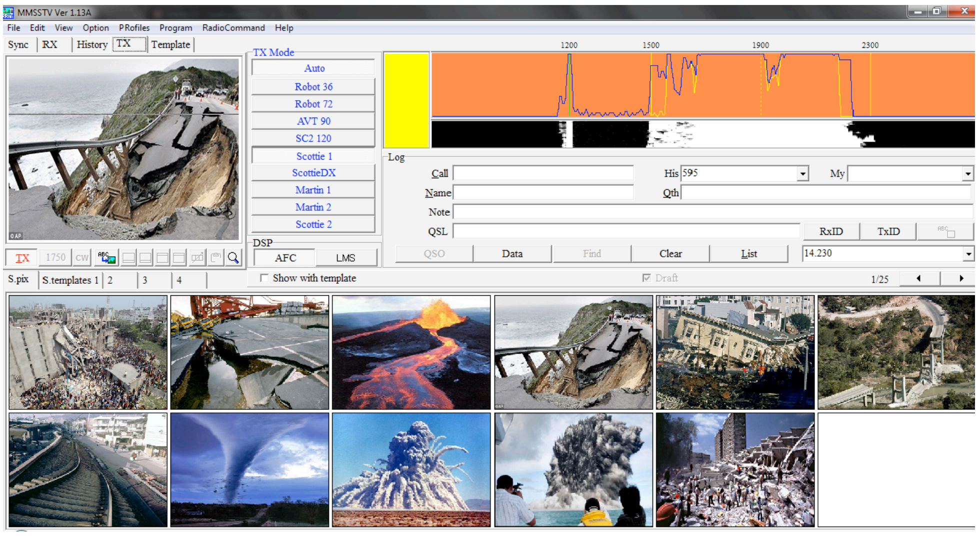


Figure 17: SSTV Interface

In SSTV Software, the transmission consists of horizontal lines, scanned from left to right. The color components are sent separately one line after another. The color encoding and order of transmission can vary between modes. Most modes use an RGB color model and some modes are black-and-white, with only one channel being sent. The other modes use a YC color model, which consists of luminance (Y) and chrominance (R-Y and B-Y).

The modulating frequency changes between 1500 and 2300 Hz, corresponding to the intensity (brightness) of the color component. The modulation is analogue, so even though the horizontal resolution is often defined as 256 or 320 pixels, they can be sampled using any rate. The image aspect ratio is conventionally 4:3. Lines usually end in a 1200 Hz horizontal synchronization pulse of 5 milliseconds (after all color components of the line have been sent); in some modes, the synchronization pulse lies in the middle of the line as shown in figure 18.

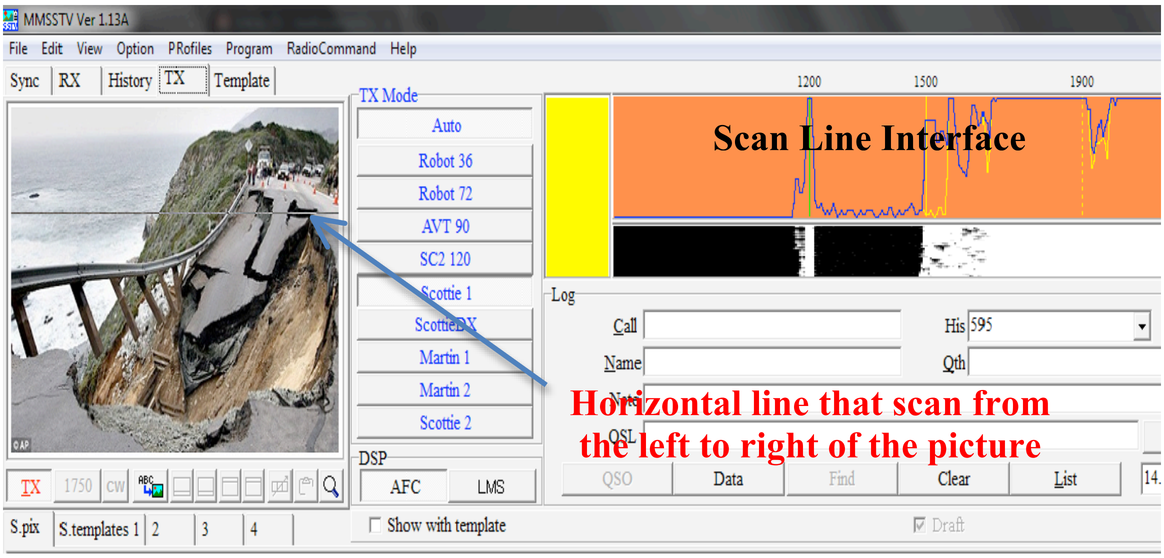


Figure 18: Example of horizontal line at the SSTV Interface

Beside that, a calibration header is sent before the image. It consists of a 300-millisecond leader tone at 1900 Hz, a 10 ms break at 1200 Hz, another 300-millisecond leader tone at 1900 Hz, followed by a digital VIS (vertical interval signaling) code, identifying the transmission mode used [16].

In addition, [15] states that there are a number of different modes of transmission, but the most common ones are Martin M1 (popular in Europe) and Scottie S1 (used mostly in the USA) as shown in figure 19. Using one of these, an image transfer takes 114 (M1) or 110 (S1) seconds. Some black and white modes take only 8 seconds to transfer an image.

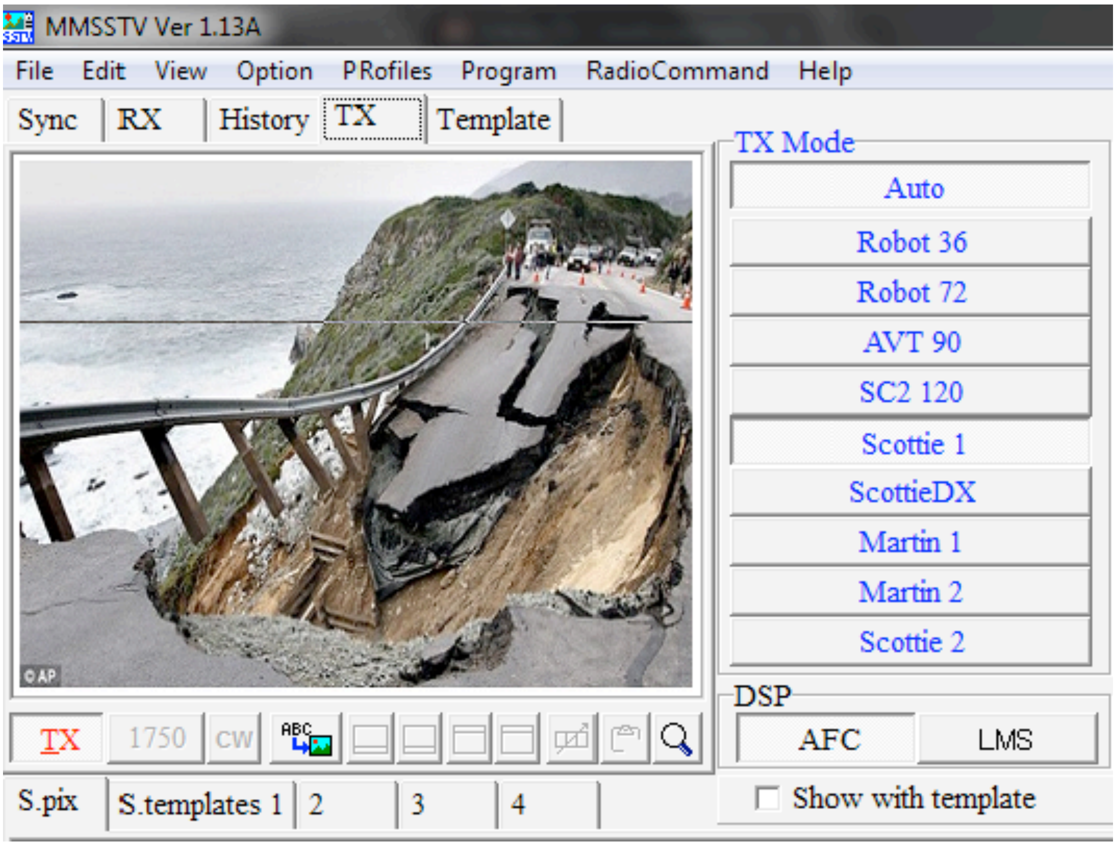


Figure 19: Transmission Mode in SSTV Interface

Table 3 is a table of some of the most common SSTV modes and their differences [15].These modes share many properties, such as synchronization and frequencies and grey or color level correspondence. The mode family called AVT (for Amiga Video Transceiver). Their main difference is the image quality, which is proportional to the time taken to transfer the image and in the case of the AVT modes, related to synchronous data transmission methods and noise resistance conferred by the use of interlace.

Table 3: Most of common SSTV Modes [15]

Mode Duration (sec)	Lines	Method
Robot 36	36	240 Color differentiation
Robot 72	72	240 Color differentiation
AVT 90	90	240 RGB (no synchronization pulse
involved)		
Scottie 1	110	256 RGB
Scottie 2	71	256 RGB
Scottie DX	269	256 RGB
Martin 1	114	256 RGB
Martin 2	58	256 RGB
SC2-180	182	256 RGB

Table 4 explain about a receiver capability of demodulating single-sideband modulation SSTV transmissions can be heard on the following frequencies [16].

Table 4: Frequencies of Modulation SSTV Transmission

Band	Frequency	Sideband
80 meters	3845 kHz (3730 in Europe)	LSB
40 meters	7170 kHz (7165 in Europe)	LSB
20 meters	14,230 kHz	USB
15 meters	21,340 kHz	USB
10 meters	28,680 kHz	USB
11 meters	27,700 kHz (Pirate Radio)	USB

4.1.2 Transmitting the Image

Transmitting an image by choosing any image from the PC in jpeg/gif type that need to be transmitting. The sound detect by the microphone will be display at the spectrum part. The image will be display as the result of the process from time domain spectrum to frequency domain spectrum. There are several steps to follow. Figure 20 is a reference to understand the steps.

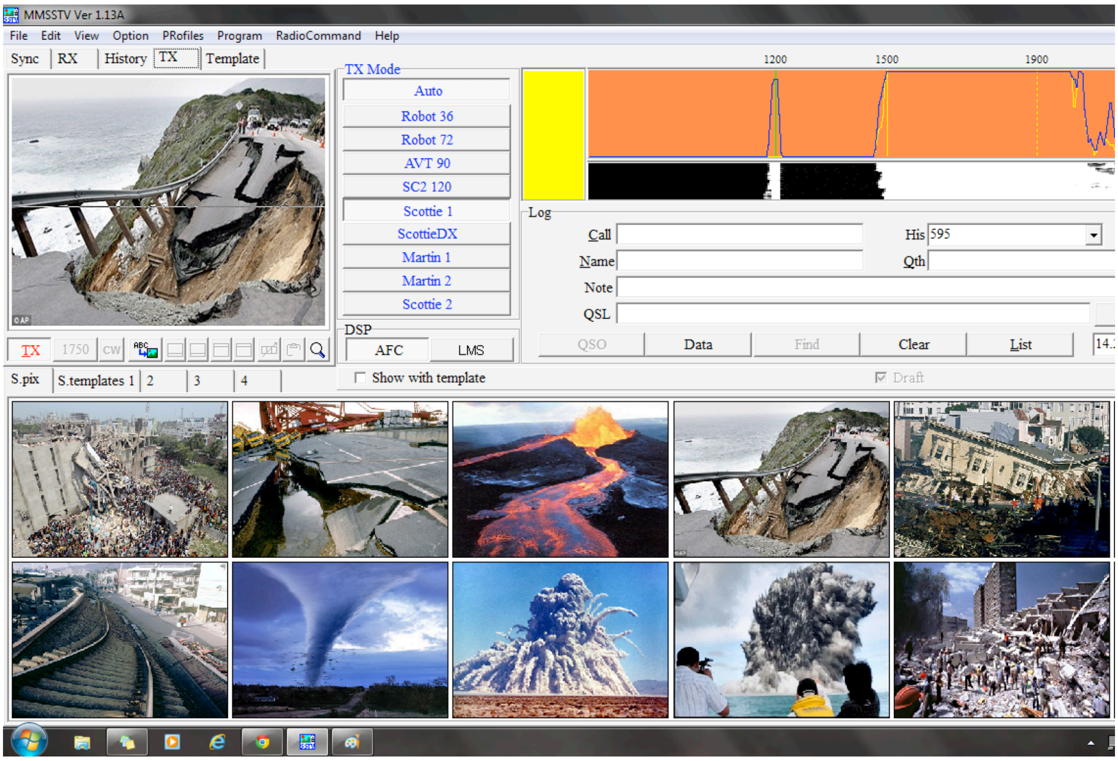


Figure 20: Full Interface of SSTV Software

1. Choose disaster image from the PC or computer in jpeg/gif/png type that need to be transmitting. Then start transmitting, by Click on the 'TX' button to start transmitting as shown in figure 21. The software will scan the picture by line and transmit the sound automatically.

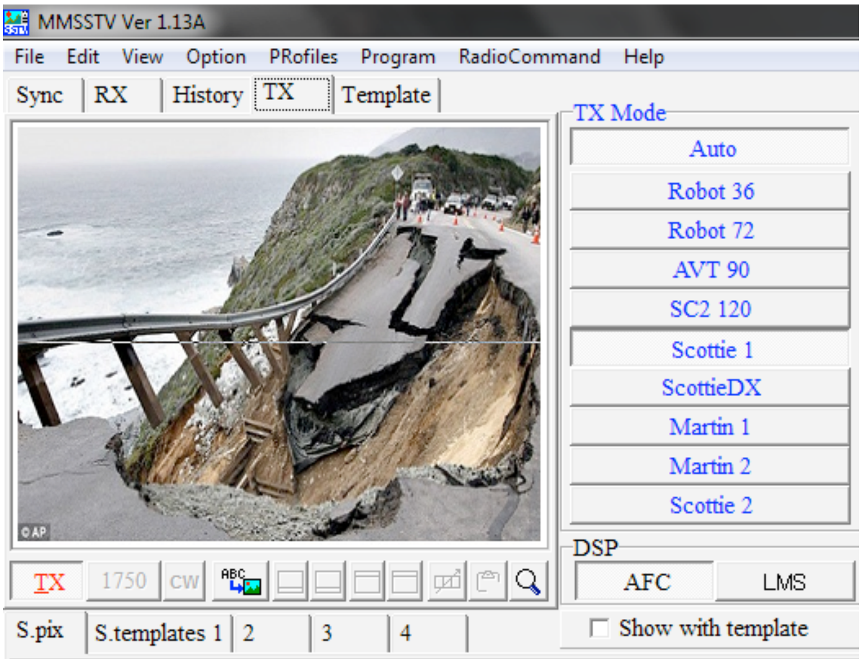


Figure 21: TX button & Modes to transmitting the image

2. Put the mouse pointer anywhere in the picture window and right click the mouse. If loading multiple pictures it may be more convenient to load them into the Stock Picture thumbnail boxes. To do this click on the "S.pix" tab and then place the mouse pointer in an empty thumbnail box and right click then continue with the following steps.

3. Click on the desired file and it will open in a 'Picture Clipper' window. This window will, among other things, proportion and resize your selected picture to fit the SSTV format (either 320x240 or 320x256).

4. Before send the image, SSTV is a 100% in duty mode like SCOTTIE 1, MARTIN 1, AMTOR FEC or RTTY as shown in figure 21 then click TX abd the image will be transmitting.

5. Disaster image is now ready to send. If you want to add an overlay template, click on the ‘Use Template’ and the currently selected overlay will be superimposed on the image.

4.2 Circuit Design and Construction Result – Phase 2

In designing and construction for the circuit, selecting suitable circuit and suitable component for the circuit is important to give the desired output. This interface has two main functions. First is used for modulating the phase of a reference signal (the carrier wave) and connects the PC or computer with the transceiver. Second the interface function is to control the PTT (push-to-talk) button. Thus the suitable schematic for PSK interface have been selected and succesfully fulfill the two main functions.

Figure 22 is the schematic of PSK interface that have been construct and tested for this project. This interface also works for SSTV, RTTY and DigiPan and this interface with the Icom IC-V8 (Transceiver). The interface requires no external power and is operated by the computer's serial port. The circuit consists of a BC548 transistor, 2 capacitors, a 5.6k-Ohm (GBR-G) resistor, and 2 LED.

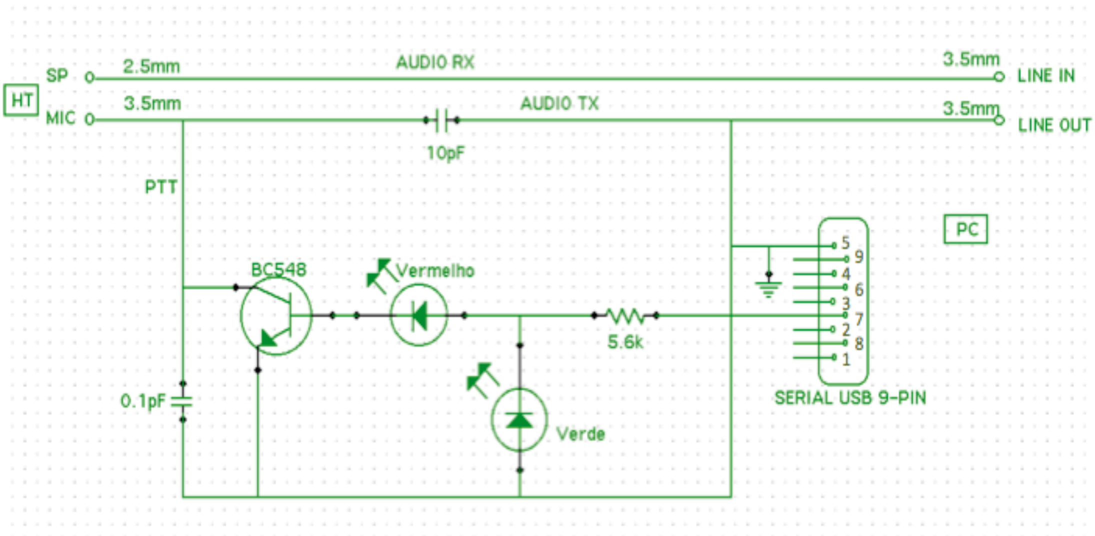


Figure 22: Schematic for PSK Interface

The circuit can be simplifying by omitting the audio level components and also by using the sound card controls from the computers operating system itself. The connections to the PC or computer sound card are made through two shielded audio cables, which are plugged into the sound card input and output jacks. The PTT and PSK Interface circuits are connected to the computer's serial (EIA-232) port through a shielded cable terminated in a nine-pin connector.

Figure 23 is a complete prototype of PSK Interface from the schematic circuit that has been selected. When the appropriate serial port signal goes "high" the LED activates and turns on the transistor, so that the connected circuit (PTT or FSK) is grounded. When the PTT is not being triggered, this shield is isolated from the "land" in DC, and the 0.1 uF capacitor ensures grounding AC (alternating current audio) because the signal is transferred by infrared light, there is no DC connection. The red LED for transmits light and green LED for the received light in the front side of the box. Probably the most important part of the layout is to provide two separate grounds, one for PC-connected components, and one for radio-connected components.

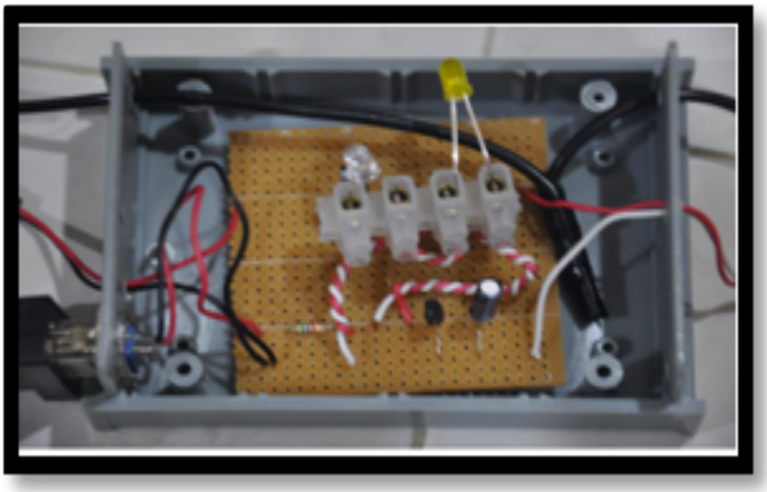


Figure 23: PSK Interface Prototype

4.3 Software & Hardware Implementation Result – Phase 3

The complete hardware setup for this project is consists of laptop, interface and 2 walkie-talkies as shown in figure 24. For the transmitter part, the laptop will connect to the walkie- talkie by interface. While at the receiver part, the walkie-talkie can be put nearby the microphone of the laptop and smart phone. The volume of the walkie-talkie should be high to avoid unwanted signal such noise.

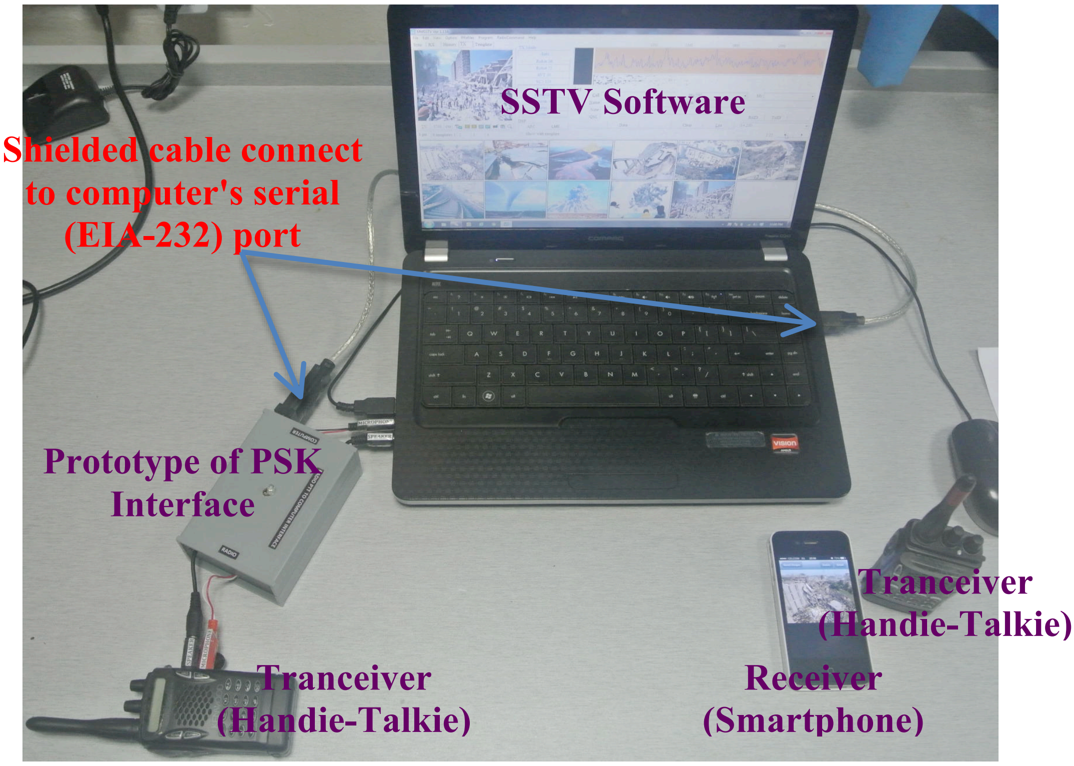


Figure 24: The Overall System of the PSK Interface Prototype and SSTV Software

4.4 Result of Test Performace

SSTV acts as an input to the system whereby it sends data to the server. On the other hand, the results of the image sent by the SSTV through the PSK Interface will be save and execute the data. To know this project is successfully transmitting the image, the result has been recorded and tested in two main factors, there are:

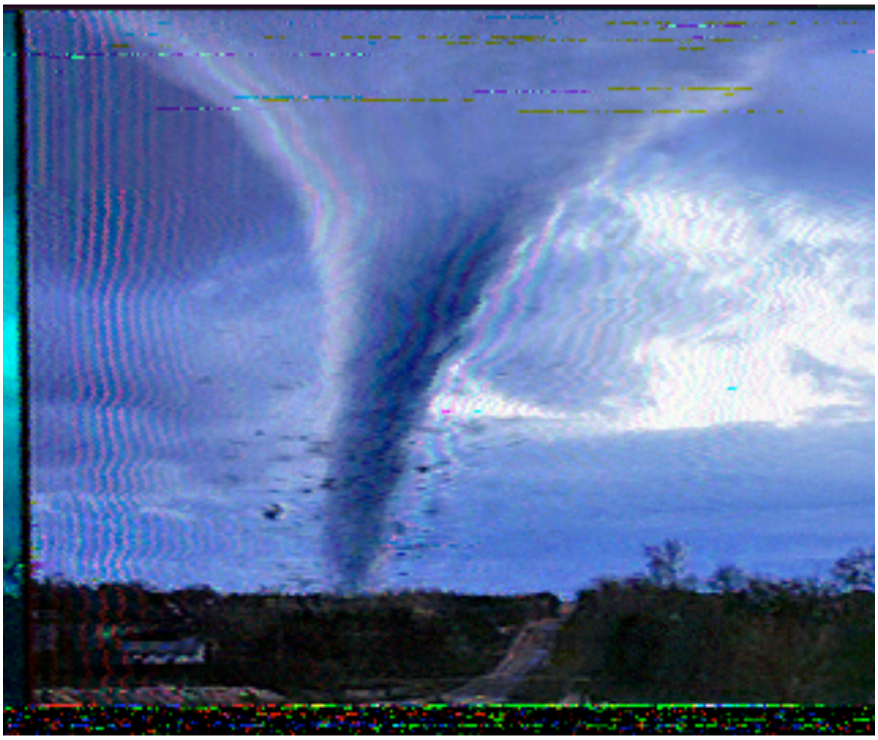
1. Distance of the transceiver from the PC or laptop to the smartphone (receiver)
2. Volume of the Handie-Talkie (as a transceiver).

4.4.1 Results and Discussion based on the Distance

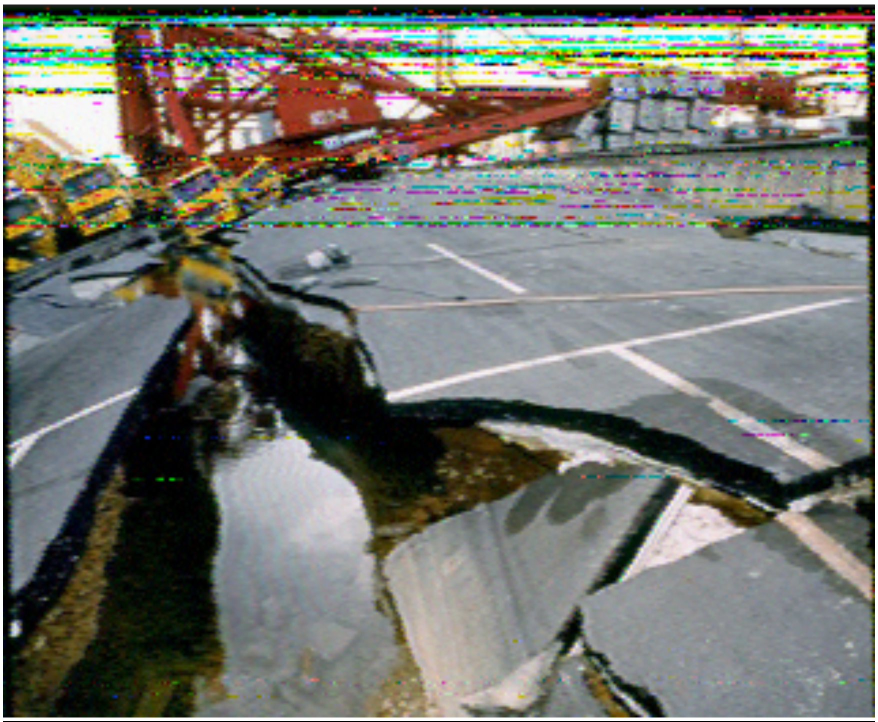
This handie-talkie is specifically built in maximum range of 5km to 10km and transmitting through VHF frequency range (1m – 10m). To test the availability of the range, the complete prototype for transmitting the image has been setup. Table 5 is the result of the transmiting image by the distance.

Table 5: Results based on the Distance

Distance: 1meter **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -108.6 Seconds (Not Including Header/Vis) **Size:** 61KB	

Distance: 3.35m / 11ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -110.9s (Not Including Header/Vis) **Size:** 45KB	
Distance: 12.8m / 42ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -113.6s (Not Including Header/Vis) **Size:** 53KB	

Distance: 21m/70ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -129.6 Seconds (Not Including Cal. Header/Vis) **Size:** 57 KB	
Distance: 34m/112ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -122.4s (Not Including Header/Vis) **Size:** 57KB	

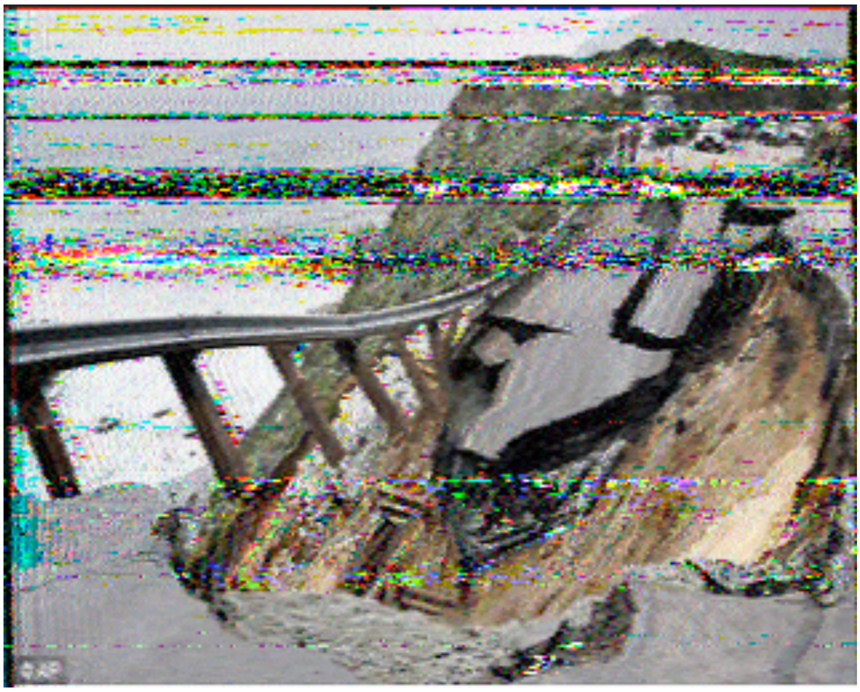
Distance: 34m/112ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -119.6s (Not Including Header/Vis) **Size:** 53 KB	
Distance: 45m/147ft **Color Mode Rgb:** (1500-2300hz Luminance Range) **Number Of Lines:** 256 **Normal Display Res:** 320x256 (Including 16-Line Header) **Transmission Time:** Scottie 1 -120s (Not Including Header/Vis) **Size:** 57 KB	

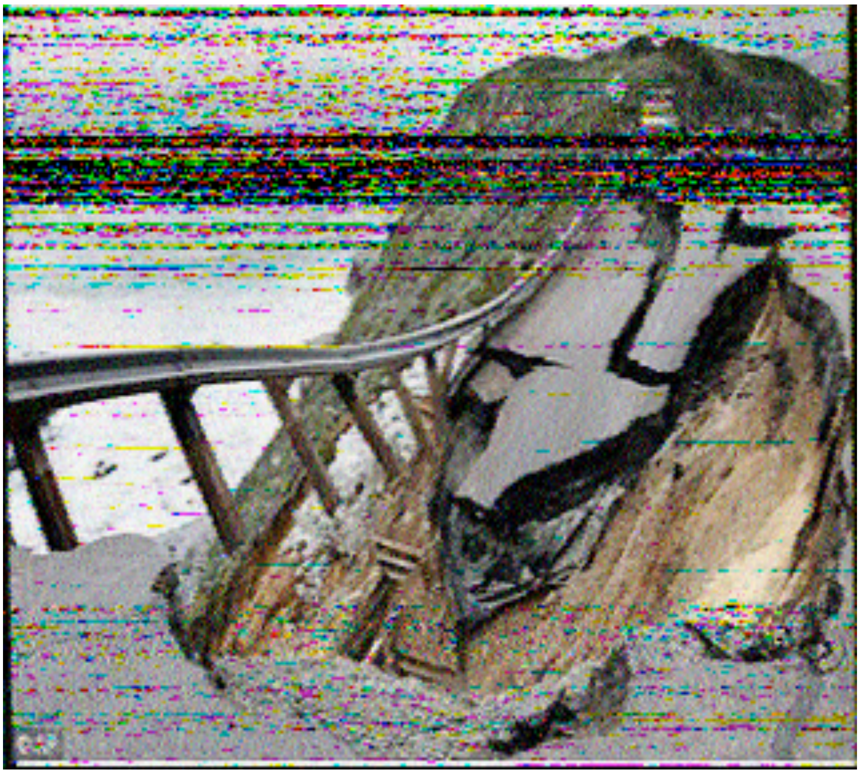
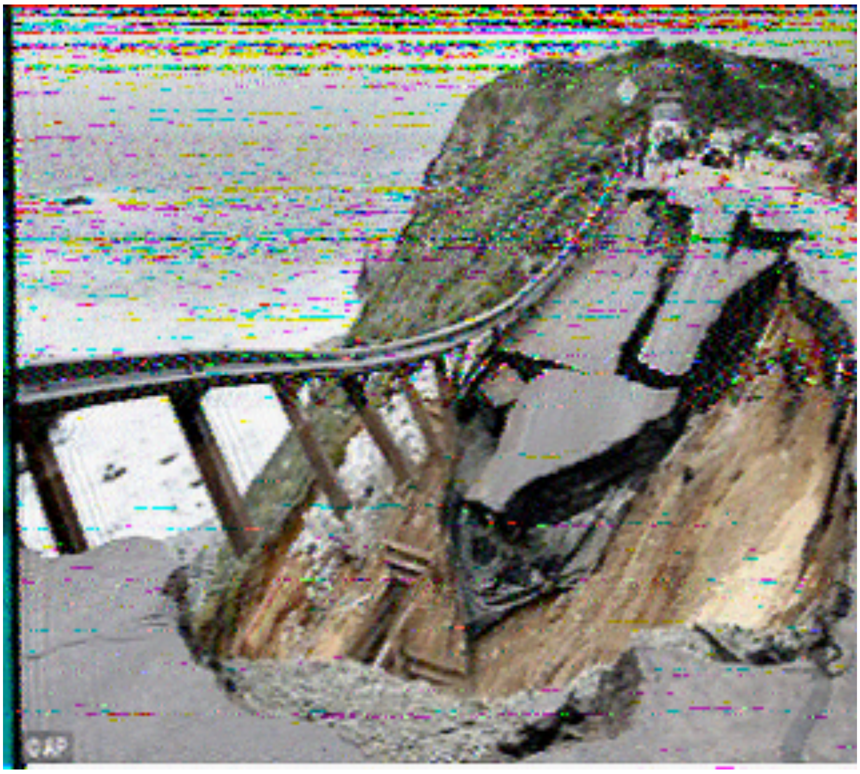
Based on the transmitting image result as shown in table 5, this PSK Interface prototype and SSTV software successfully achieved the objective of this project. The image transmission has been trasmit in RF range which is in Very High Frequency (VHF) frequency band around 1 meter until 10 meters. The far distance that has been tested was 45 meters or 147 feets and the handie-talkie distance are also within the range (5km) during the image transmission.

4.4.2 Results and Discussion based on The Volume of Handie-Talkie

In this result, volume of the walkie-talkie also one of important factor when trasmitting the image. The result has been record and compare by transmitting an image with different level of volume. The volume should be high to avoid unwanted signal such noise and adjust it at the handie-talkie during the transmitting process. Table 6 is the result of the transmitting image by using a diffirent volume level.

Table 6: Result based on the Distance

	The volume level has been tested by using same picture to see.
Condition 1: 5% volume of handie-talkie	 • The image received was not very clear and have bit error because of noise and the volume is slow during the transmitting.

Condition 1: 25% volume of handie-talkie	
Condition 1: 50% volume of handie-talkie	

Condition 1: 100% volume of handie-talkie	 • The image received was clear compared to the 5% volume image and have less bit error.

4.5 Data and Analysis of Test Peformance

The results of the test performance has been recorded and analysed. From the test performance results, the received image will have noise during trasmission. Therefore, MATLAB® software has been selected to analyse the noise by using PSNR (Peak Signal to Noise Ratio). Peak Signal to Noise Ratio is the important parameters to analyze the image. The PSNR is most commonly used as a measure of quality of reconstruction of image. The signal in this case is the original data, and the noise is the error introduced by the received image. The PSNR is defined [19,20] as shows in figure 25:

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right)$$

Figure 25: Peak Signal to Noise Ratio Equation [19,20]

The noise has been detected by MATLAB® software coding and the PSNR result shows in figure 26 and figure 27 is the function of PSNR. The results have been plotted based on the values that achived from the MATLAB® Software.

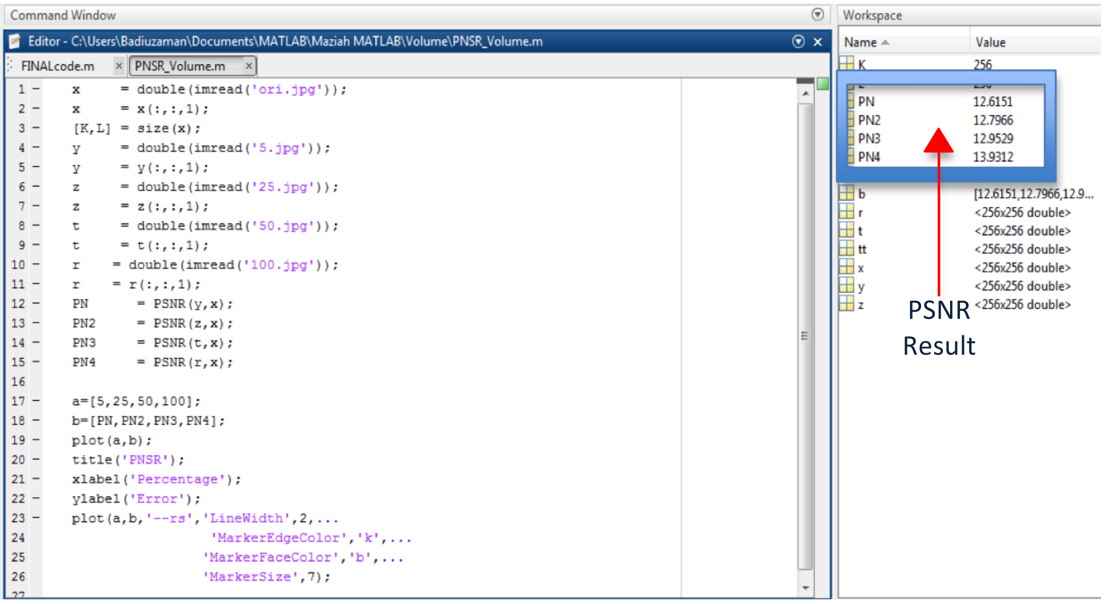


Figure 26: Coding of PSNR Volume

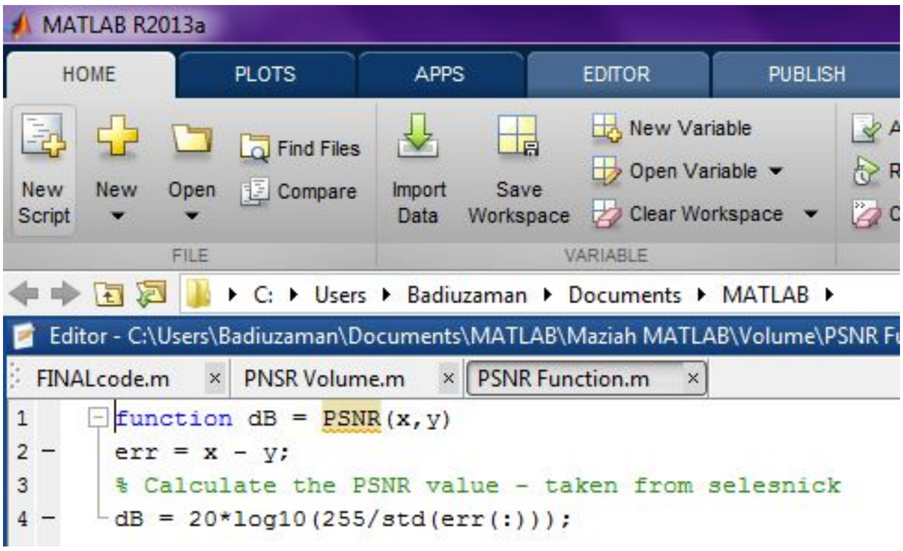


Figure 27: Coding of PSNR Function

The value of PSNR has been plotted in a graph as shown in figure 28, the x-axis is the percentage of handie-talkie volume and the y-axis is the result of PSNR Error from MATLAB® coding. The result shows that PSNR value was high when the handie-talkie's volume at 100% either than at 5%. Based on [21], high value of PSNR obtain from the received image shows that the image quality is good; with low noise and nearly to the original image that has been transmit. Image received from the test performance has been proved by the result obtain from the PSNR coding using MATLAB® software. Therefore, it can be conclude that the volume of handie-talkie should be higher during the image transmission which is between 75% to 100% to get desired image or output.

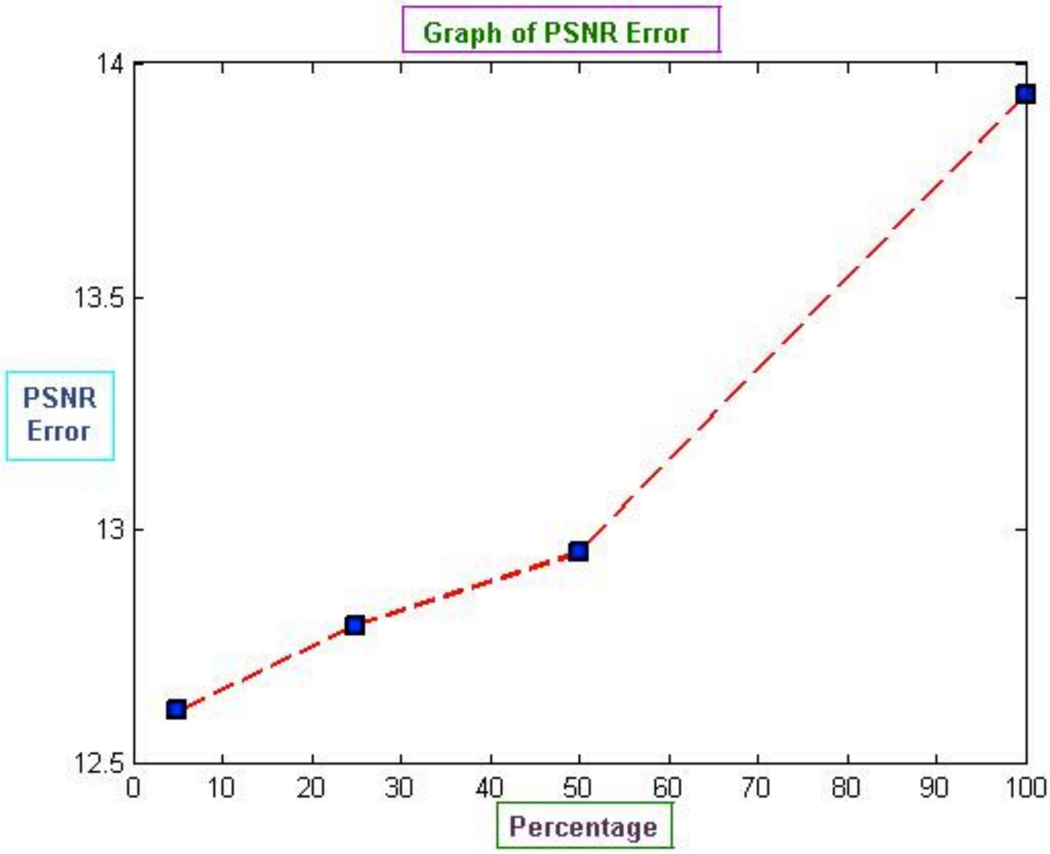


Figure 28: Graph of PNSR Value for Volume Test Performance

Furthermore, the distance's result from the test performance also has been analyzed by the MATLAB® coding as shown in figure 29. The received image has been compared with the original image to obtain the PSNR error for each picture that has been transmitted.

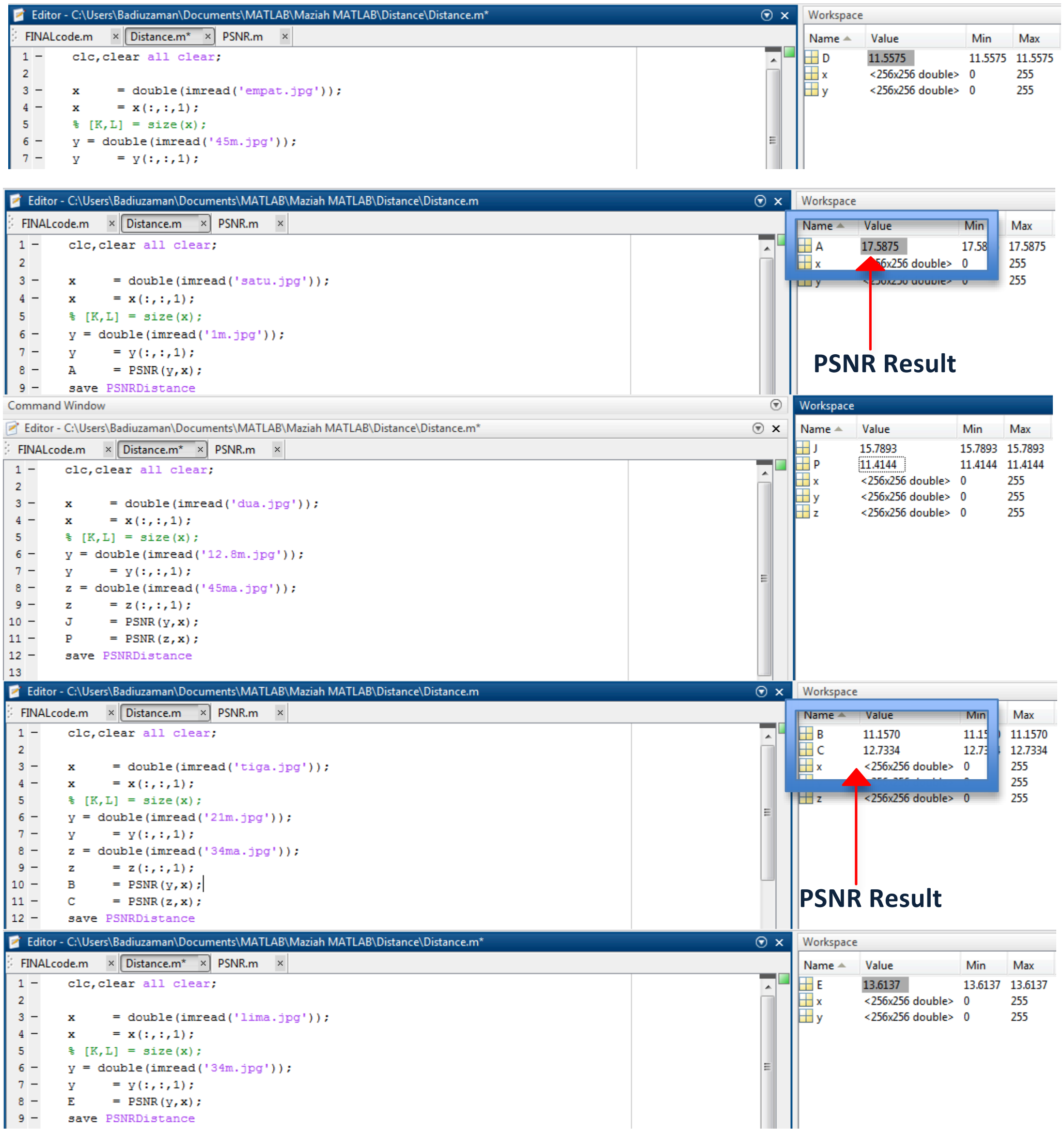


Figure 29: Coding PSNR for Distance

The PSNR value obtained from the analysis has been recorded in table 7.

Table 7: PSNR Error based on distance

No of Test	Distance (meter)	PSNR Error (dB)
1	1	17.58753954
2	3.5	9.363434671
3	13	11.41436712
4	21	11.15703166
5	34	12.73336687
6	34	13.613745
7	45	11.55753652
8	45	15.78931607
Average		**12.90204218**

Figure 30 shows the graph of PSNR error based on the distance in the test performance. The x-axis is the distance in meter between transmitter and receiver, the y-axis is the result of PSNR Error from MATLAB® coding. From the graph, the average of the PSNR has been calculated and the average is 12.9 dB.

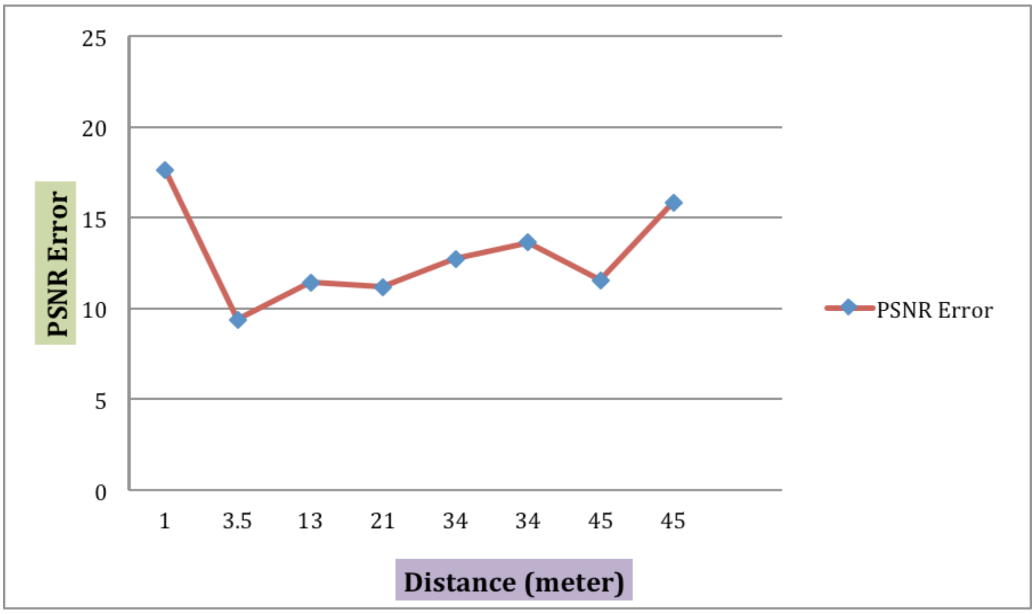


Figure 30: Graph of PNSR Value for Distance Test Performance

RECOMMENDATION

Usually people want to receive a perfect high-resolution color pictures with motion under weak communication signals. Thus, the development of transmission an image by using SSTV is still in area of amateur radio where there is plenty of scope for future developments. It hopes that any dedicated person willing to pick up the challenge and work toward to build the ultimate transmission mode. Such a simple walkie-talkie with built-in camera so there is no need a PC to integrate with the transceiver. Therefore, the basic idea by using PSK as a interface also can be improve by built it in different type of PSK such as QPSK (Quad Phase-shift keying), BPSK (Binary Phase-shift keying) and HPSK (High Phase-shift keying).

Furthermore, the developments of image transmission using RF can be implement into a system that can even receive an image from the satellite. But there is a limitation to doing it because the amateur radio needs to be register and the user must have a license. Therefore, this final year project have has been designed and tested by using radio frequency transmission system which is handie-talkie.

Most of the user want to receive a perfect high-resolution colour pictures with motion as an extra under the very worse communication conditions. Thus there are always have a way to develop, SSTV is still in area of amateur radio where there is plenty of scope for future developments. It hopes that any dedicated person willing to pick up the challenge and work toward to build the ultimate transmission mode. Such a simple walkie-talkie with buit-in camera so there is no need a PC to integrate with the transceiver.

CONCLUSION

A powerful, but low cost, digital image processing system has been research, designed, constructed, programmed and made operational. Unique "line buffer" architecture and the use of the most advanced 8-bit MOS microprocessor give the system powerful software capabilities. Costs have been kept down by limiting the image quality to SSTV standards and by employing the computer bus with the widest selection of options and vendors. A unique, all digital, method of encoding and decoding SSTV signals allows experimentation and measurement by changing program variables. An easily expanded base of image processing programs has been developed. These include powerful functions such as two dimensional convolution, point processing, and average noise removal.

For Final Year Project I, the first stage of the system, constructing the PSK interface 1 circuit, testing and troubleshooting has successfully been implemented. But the output of the schematic was failed because the PSK interface 1 disable to control the PTT (push to talk) function.

The second stage of the project will be testing the PSK interface 2 circuit that has been designed and construct it as a sucessful prototype. The main objective of this final year project has been archived, the complete prototype of this project was successfully transmit the image to a reciever as per shown on the results section in this report. The results of the test performance also has been recorded and analysed by using MATLAB® Sofware. In addittions, this project has been tested into two factors which is the distance of the receiver and also the volume level of the handie-talkie and saved the image as a results and also shown in this report.

For the conclusion, recommendation and future enhancement is to give an opportunity to other researcher is to provide an idea to improve the project to another level. This project has a chance to produce in a model that can be commercialized. This will encourage any researcher to develop this idea because it will give a profit when the model can be selling in market.

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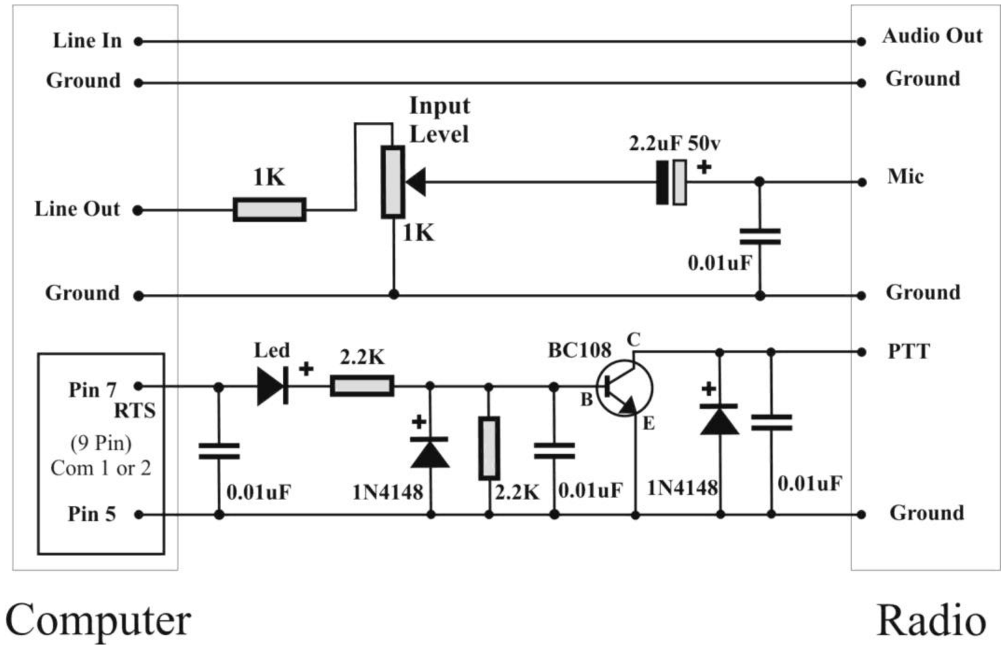
APPENDICES

APPENDIX 1: Final Year Project Cost

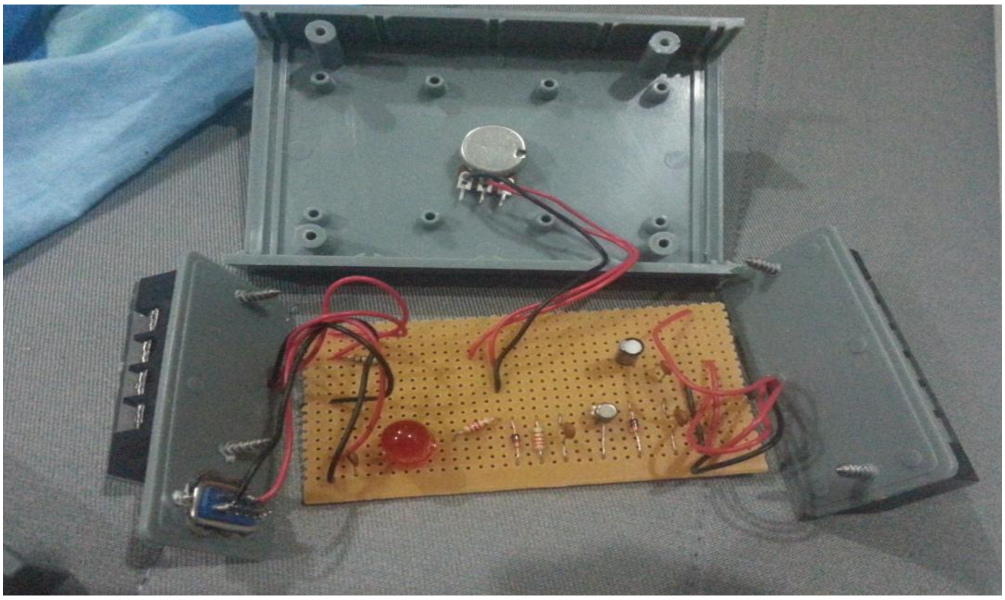
NO	HARDWARE	QUANTITY	PRICE (RM)	TOTAL (RM)
1	Resistor 1/4W	8	0.05	0.4
2	Transistor BC 548	2	0.4	0.8
3	E-cap 0.1u	4	0.2	0.8
4	LED Blue and Yellow	4	0.6	2.4
5	Veraboard small	2	1.5	3
6	3.5 audio jack	4	0.5	2
7	3.5 to 2.5 audio adapter	2	9	18
8	Box	2	5	10
9	2 meter wire	1	2	2
10	Walkie-talkie	2	140	280
11	9 pin to USB Cable	2	12	24
12	Black Cat Software	1	10	10
				RM 353.4

APPENDIX 2: Second Attempt Circuit - Failed

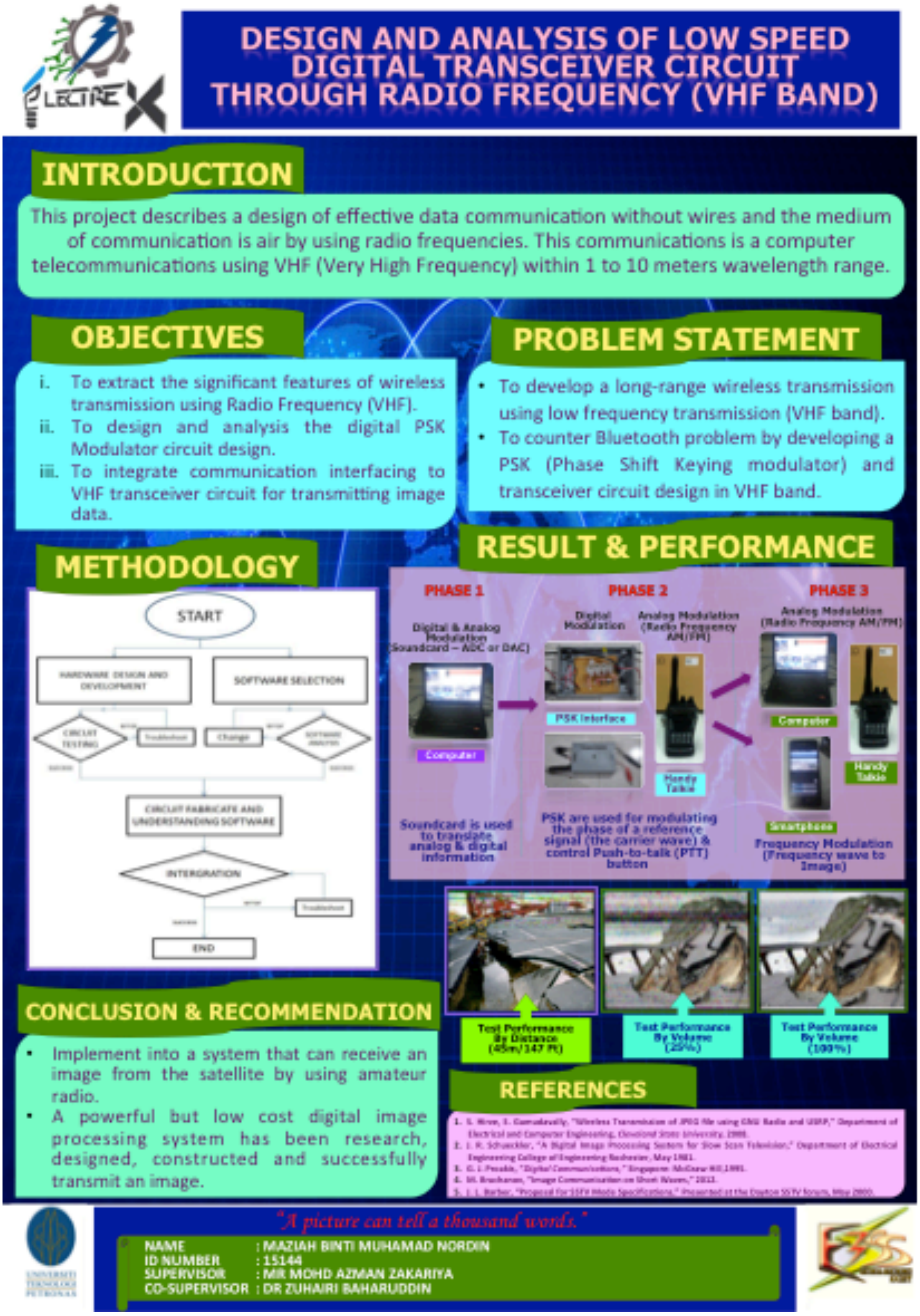
Interface Schematic



The Circuit Prototype



APPENDIX 3: Presentation Poster



APPENDIX 4: Troubleshoot Pictures