

Developments of Real Time and Low Cost VHF/UHF Data Acquisition System

E. Z. Idris,

Faculty of Electrical Engineering, UiTM, Shah Alam, Malaysia

Abstract— Very High Frequency (VHF)/Ultra High Frequency (UHF) plays a significant and vital role in our daily communications life. Thus, making it crucial to develop a data acquisition system to assist and facilitate further research and studies on VHF/UHF such as in amplitudes variations due to propagations characteristics. Currently, available data acquisition systems are very expensive, complex (non-user friendly), rigid and limited capabilities due to its hardware restrictions/limitations. Consequently, a real-time and low-cost data acquisition system was developed by using microcomputer (Raspberry Pi 3b) and Software Defined Radio (SDR). The system successfully acquired and collected relevant data (frequency amplitudes) that would be resourceful for further analysis and studies of the VHF/UHF signals.

Index Terms—VHF, UHF, SDR, Data Acquisition System

I. INTRODUCTION

Radio Frequency plays a significant and vital role in our daily communications life. From voice to data, VHF/UHF applications throughout day-to-day activities has driven us to further studies the VHF/UHF characteristics due to propagations.

A. Radio Frequency Propagations

Signals propagations explain the way radio frequency propagates from an antenna of a transmitter to the other end of receiving antenna. The propagation is affected by various ways depends on the medium and propagation methods used.

1) Ground wave

Signals that travel along or close to the Earth's surface on their path between transmitting and receiving antenna are called Ground Wave. Due to the Earth poor electrical conductor characteristics, the ground wave strength diminishes rapidly with distance. The attenuation of the surface wave signals also increases rapidly as the frequency increased. Its frequency ranges from VLF (3-30 kHz), LF (30-300 kHz) to MF (300-3000 kHz). Applications varies from Navigations, Space Weather study and long range communications.

2) Sky wave

Travelling signals that reflected back by the ionospheric layers are called sky wave. HF (3-30MHz) operated by Sky Wave and is highly affected by the ionospheric refractions. Amateurs and military are still using it for long-range communications.

3) Direct (Line of Sight – LOS) Wave

Direct wave depends on LOS between transmitting and receiving antenna. Thus, increasing the distance of transmission requires increasing the height of the antenna location above the terrain. However, certain frequencies are still affected by ionospheric refraction and tropospheric ducting. It covers from VHF (30-300 MHz), UHF (300-3000MHz) to SHF (3-30 GHz). Applications ranges from broadcasting, short-range communications, navigations to satellite communications.

Previous data acquisition system on radio frequency requires expensive equipment such as Spectrum Analyzer and with limited capabilities due to hardware limitations. By integrating the microcomputer and SDR, a real-time and low-cost data acquisition system could be developed to reduce and simplify methods for studying radio frequencies.

C. Microcomputer

Microcomputer is a small computer equipped with a microprocessor. In this system, microcomputer was used as an alternative to personal computer (PC) due to its system portability, simplicity and robustness as well as low cost and low powered. Managing the database acquired thru the system will mainly done by the microcomputer. There are various types of microcomputer including the Raspberry Pi. The Raspberry Pi is a credit-card-sized computer (microcomputer) that plugs into a TV and a keyboard. [1]. It is a multipurpose and versatile little computer that can be programmed to perform various tasks such as automation, cloud server and many other more. The Raspberry Pi 3b (hereafter simply referred as Raspberry Pi) is the third generation Raspberry Pi and is equipped with a 1.2GHz 64-bit quad-core ARMv8 CPU, 1GB RAM and others such as Wireless LAN and Bluetooth. It is also requires low power at only 2.5A.

D. Software Defined Radio (SDR)

A simple description of an SDR is that it is a radio which is divided into two parts. One part is the analog front-end, which

deals with antenna transmission and reception, filtering, amplification and frequency shifting to/from an intermediate frequency. The second part is a digital back-end, which processes the baseband signal and is done thru software [2].

SDR receives analog signal and uses the Analog to Digital Converter (ADC) to digitize the signal. Then the digitized signal could be processed via software. It is possible to have a completely different communication system just by replacing the software that is executed, keeping the same hardware [3]. From Frequency Modulation (FM) as an example, a digital modulation can be attained thru software without any modifications on the hardware. Thus its versatility has big impact on the telecommunications field, from students in laboratory to the industrial and researchers in the field. such as in Cognitive Radios.

RTL-SDR is a custom driver software that operates a USB digital TV tuner to function as a software defined radio receiver [4]. It is an open source software developed by Osmocom [5]. The driver works on digital TV tuners based on the Realtek RTL2832U data acquisition chip [6]. The USB digital TV tuner contains two main integrated chips (IC) which are used for receiving signals and data acquisitions and sending it to computer for digital signal processing. The RTL2832U has a 8-bit ADC which can worked up until 28.8MHz. Digitizing higher frequency requires IF mixer to convert it which used the R820T tuner chip. It operated from 20 MHz to 1.7 GHz and has a maximum bandwidth of 3.2 MHz. Its also come up with Low Noise Amplifier.

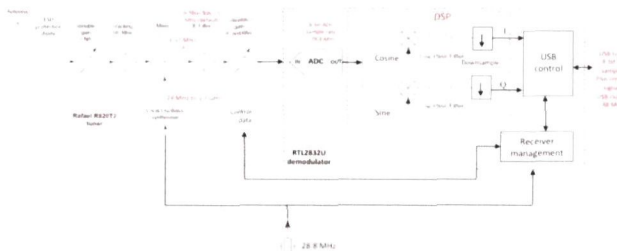


Fig 1. RTL-SDR Diagram Block [7]

There a few other models with broader capabilities such as the HackRF and the Ettus Research USRP (Universal Software Radio Peripheral). These models are expensive than the RTL-SDR but still at affordable price compared to others high end SDR.

II. METHODOLOGY

Development of the data acquisition system includes setting up the systems - hardware and software. Hardware implementations and set-up include connecting all the required hardware such as an antenna (Omni-Directional used), relevant RF connectors (such as BNC, SMA and MCX) and coax cables, RTL-SDR, Raspberry Pi and relevant network connections.

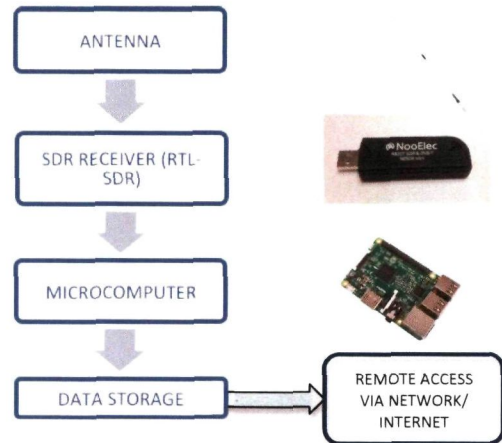


Fig 2. Hardware Set-up.



Fig 3. Location of antenna at an antenna tower in Sg Besi, Kuala Lumpur.



Fig 4. Completed connection to the Raspberry Pi.

After all hardware implemtion had been completed, the appropriate system's software was prepared and set-up. These includes:

- 1) Installing the Raspbian Jessie (Linux OS).
- 2) Preparing network connections such as creating an access point (AP) and setting up a connection via Secure Socket Shell (SSH) server for remote access.
- 3) Installing relevant software and software packages that include the *rtl-sdr* drivers and packages (includes *rtl_power* function), SDR GUI software and Python.

The *rtl_power* is a new command (tool) in the SDR that allows us to capture a whole band of frequency spectrum base on our requirement. Data obtained using this command includes data and time, frequencies and amplitudes. It will produce a comma separated values (csv) [8].

There are varieties of open source SDR receiver software that are available that came up in Graphical User Interface (GUI) to allow easier access to the SDR receiver. This includes SDR Sharp, GNU Radio and Gqrx. Gqrx is an open source software defined radio receiver (SDR) powered by the GNU Radio and the Qt graphical toolkit [9].

In this system, Gqrx was used as it has compatibility with the Linux. This software will be utilised as a tool for real-time monitoring of the frequency spectrum.

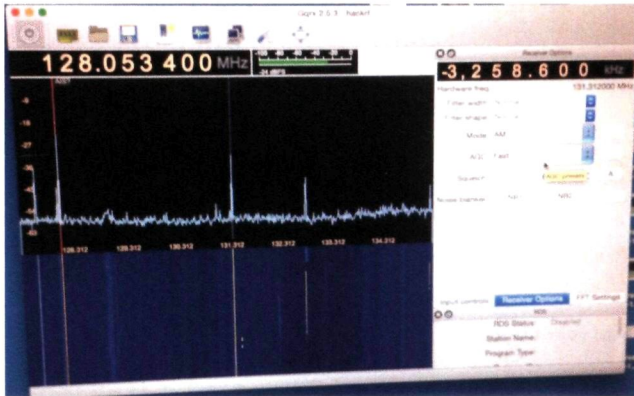


Fig 5. Gqrx interface.

Python is an interpreted, interactive, object-oriented programming language [10]. It has fewer lines code, open source and can run on various OS such as Microsoft Windows, Linux. Few Python commands were used as there were abundant of resources that could be found and used. This includes the heatmap.py [11] command that will render graphics of the overall spectrum (data) collected/acquired.

Once all relevant and necessary software and packages were installed, automation was set up for the Raspberry Pi to execute `rtl_power` command using the `crontab` at a specified interval. In this system, the `rtl_power` command was executed to run for a duration of 23 hours for every day. Example of command executed:

```
$ rtl_power -f 30M:300M:100k -g 50 -i 10 -e 23h >>
/media/pi/Seagate\ Backup\ Plus\ Drive/SDR_Data/AlphaVHF100k$(date +%d%b%Y).csv
```

Real-time monitoring of the data acquisition could be done by using the command `tail -f filename`. This command will help if we want to check the integrity of the data collected/recorded.

```
000Alpha_media_pi/Seagate_Backup_Plus_Drive/SDR_Data/1611_1_1AlphaVHF100k19Dec2016.csv
1812 12 19 09 42 35 273264979 249404899 80884.53 532 26.66 25.81 24.81 28.35 28.83 25.22 28.28 22.83 24.52 27.43 28.94 27.27 21.22 28.56 25.96 28.29 19.35 19.45 18.86 21.82 19.82 22.65 21.97 18.17 18.41 11.29 19.47 22.86 24.18 26.84 21.11 25.19 12.25
1812 12 19 09 42 35 274044448 277193444 80884.53 532 28.54 28.57 27.68 28.81 28.86 27.84 25.88 18.86 17.38 26.82 27.82 27.92 23.97 21.86 24.87 26.77 26.57 18.24 19.38 26.51 24.81 21.78 18.88 15.88 23.21 27.87 29.78 25.88 27.48 18.53 21.8
1812 12 19 09 42 35 277733845 288515489 80884.53 532 22.86 26.87 26.88 26.33 25.72 23.21 24.82 24.49 28.52 18.81 11.85 19.85 13.22 22.57 23.86 21.18 5.38 5.08 16.84 28.88 22.53 22.85 22.89 17.88 13.35 19.89 18.31 21.71 28.91 22.37 18.57 14.84 14.84
1812 12 19 09 42 35 288535498 283280954 80884.53 532 22.71 23.29 22.86 23.44 21.88 14.25 16.57 11.89 1.38 14.53 19.82 19.88 1 1.96 14.28 18.42 28.12 19.86 17.86 13.75 1.98 8.83 16.42 18.86 16.44 13.76 18.87 19.57 16.82 8.39 5.83 13.86 18.35 1 1.31
1812 12 19 09 42 35 293289955 288824559 80884.53 532 25.78 22.75 22.24 21.29 17.56 9.45 4.44 11.37 14.58 18.87 28.48 22.15 22 1812 12 19 09 42 35 293889564 288859664 80884.53 532 18.86 26.66 24.86 24.85 22.72 14.83 16.88 11.74 18.88 18.38 28.12 28.21 18.81 18.88 18.88 18.88 17.74 17.74 14.18 11.78 21.48 22.88 28.88 28.88 21.24 21.51 17.88 11.88 19.52 22.78 25.1 25.38
1812 12 19 09 42 35 298885965 293484888 80884.53 532 27.18 28.75 24.18 17.81 14.88 12.88 18.35 19.42 21.53 22.83 22.89 23.13 18.12 21.31 11.82 18.83 21.88 22.43 22.48 21.45 13.78 17.33 22.55 23.85 19.31 18.56 13.78 21.79 25.87 27.82 26.7 26.88
1812 12 19 09 42 35 298889498 294432974 80884.53 532 18.41 11.86 29.97 27.85 23.87 22.57 24.85 17.81 17.82 23.38 24.27 24.82 17.11 23.18 28.77 21.81 28.69 28.69 18.29 23.28 19.62 15.89 22.15 22.31 23.88 25.88 25.87 25.85 25.65 27.12 28.28 18.4 18.41
1812 12 19 09 42 35 298892975 297184779 80884.53 532 28.87 28.58 27.88 19.18 23.71 22.76 22.77 21.71 18.88 11.71 18.82 21.59 18.82 21.39 18.82 21.39 28.34 24.33 24.33 23.64 18.29 28.78 24.85 25.83 24.51 22.88 18.33 22.25 27.47 25.81 25.84 27.1 27.15
1812 12 19 09 42 35 299731888 299999984 80884.53 532 18.21 18.17 28.88 24.46 28.88 25.87 24.46 22.58 23.99 18.57 18.79 24.83 25.88 28.19 24.42 18.96 18.65 19.65 25.82 25.88 23.12 25.38 28.17 24.88 24.47 28.12 22.85 17.42 23.12 25.15 29.59 18.9 18.91 18.82
```

Fig 6. Real-time display of data being acquired/captured.

III. RESULTS

The system operated for more than 10 days to acquired the data. Data collected were in csv (comma separated values) format and could be easily imported to Microsoft excel or Matlab for further analysis.

Name	Date Modified	Size	Kind
Alpha01Dec2016.csv	2016-12-01 10:00:00	1.0 MB	File
Alpha02Dec2016.csv	2016-12-02 10:00:00	1.0 MB	File
Alpha03Dec2016.csv	2016-12-03 10:00:00	1.0 MB	File
Alpha04Dec2016.csv	2016-12-04 10:00:00	1.0 MB	File
Alpha05Dec2016.csv	2016-12-05 10:00:00	1.0 MB	File
Alpha06Dec2016.csv	2016-12-06 10:00:00	1.0 MB	File
Alpha07Dec2016.csv	2016-12-07 10:00:00	1.0 MB	File
Alpha08Dec2016.csv	2016-12-08 10:00:00	1.0 MB	File
Alpha15Nov2016.csv	2016-11-15 10:00:00	1.0 MB	File
Alpha17Nov2016.csv	2016-11-17 10:00:00	1.0 MB	File
Alpha18Nov2016.csv	2016-11-18 10:00:00	1.0 MB	File
Alpha19Nov2016.csv	2016-11-19 10:00:00	1.0 MB	File
Alpha20Nov2016.csv	2016-11-20 10:00:00	1.0 MB	File
Alpha21Nov2016.csv	2016-11-21 10:00:00	1.0 MB	File
Alpha22Nov2016.csv	2016-11-22 10:00:00	1.0 MB	File
Alpha23Nov2016.csv	2016-11-23 10:00:00	1.0 MB	File
Alpha24Nov2016.csv	2016-11-24 10:00:00	1.0 MB	File
Alpha25Nov2016.csv	2016-11-25 10:00:00	1.0 MB	File
Alpha26Nov2016.csv	2016-11-26 10:00:00	1.0 MB	File
Alpha27Nov2016.csv	2016-11-27 10:00:00	1.0 MB	File
Alpha28Nov2016.csv	2016-11-28 10:00:00	1.0 MB	File
Alpha29Nov2016.csv	2016-11-29 10:00:00	1.0 MB	File
Alpha30Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha31Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha32Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha33Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha34Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha35Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha36Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha37Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha38Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha39Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha40Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha41Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha42Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha43Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha44Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha45Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha46Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha47Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha48Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha49Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha50Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha51Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha52Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha53Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha54Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha55Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha56Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha57Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha58Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha59Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha60Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha61Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha62Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha63Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha64Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha65Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha66Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha67Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha68Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha69Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha70Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha71Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha72Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha73Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha74Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha75Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha76Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha77Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha78Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha79Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha80Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha81Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha82Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha83Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha84Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha85Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha86Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha87Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha88Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha89Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha90Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha91Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha92Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha93Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha94Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha95Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha96Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha97Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha98Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha99Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha100Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha101Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha102Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha103Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha104Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha105Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha106Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha107Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha108Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha109Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha110Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha111Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha112Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha113Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha114Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha115Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha116Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha117Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha118Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha119Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha120Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha121Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha122Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha123Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha124Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha125Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha126Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha127Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha128Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha129Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha130Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha131Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha132Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha133Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha134Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha135Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha136Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha137Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha138Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha139Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha140Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha141Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha142Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha143Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha144Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha145Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha146Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha147Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha148Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha149Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha150Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha151Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha152Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha153Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha154Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha155Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha156Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha157Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha158Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha159Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha160Nov2016.csv	2016-11-30 10:00:00	1.0 MB	File
Alpha161Nov201			

This image will give an overall visualisation of the data collected (such as time, frequencies and amplitudes) by plotting time vs frequencies vs amplitudes (intensities of the colour represent the amplitudes of the signals).

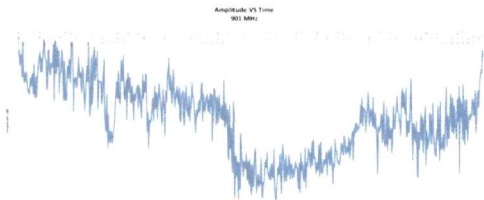


Fig 10. An example of plotted data (Time VS Amplitude) for 901 MHz.

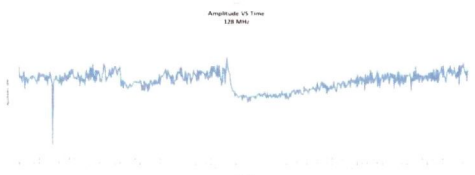


Fig 11. An example of plotted data (Time VS Amplitude) for 128 MHz.

From both plotted data as an example, we could see rapid decreased of amplitudes at around 1920H. Then it increased gradually at around 0044H

IV. DISCUSSIONS

Data collected could be used in various ways to improve our understanding of the radio frequency signals. Based on the amplitudes of the signals collected, a simple analysis such as amplitudes variations could be identified for study such as amplitudes variations due to ionospheric characteristics. Others application includes:

- 1) Spectrum survey (determine unauthorized/unregistered transmitter beacon.
- 2) Space Weather or ionospheric impact on radio frequencies signals (such as amplitudes variations).
- 3) Detecting doppler shift by using high resolution narrow band scans.

Further improvement could be implemented in this systems such as increasing the frequency covering from VLF to UHF. One of the major problem faced in this system is time taken in handling the data. This is due to the size of the data. Thus high performance computer had to be used to process the data.

V. CONCLUSIONS

The data acquisition system has been successfully been develop although with some limitations that include the frequency it can cover. Thus, increasing the frequency range by using improved SDR (higher cost but still cheap compared to others high end units) such HackRF or USRP or SDR Play that could cover from 1KHz until 6 GHz would increased further its capabilities.

REFERENCES

- [1] FAQs Raspberry Pi [online]. Available <https://www.raspberrypi.org/help/faqs/#topIntro>
- [2] Miguel Bazdresch "Considerations for the Design of a Hands-On Wireless Communications Graduate Course Based on Software-Defined Radio" Electrical, Computer & Telecom Engineering Technology Dept. Rochester Institute of Technology Rochester, NY
- [3] André L. G. Reis*, André F. B. Selva*, Karlo G. Lenzi†, Silvio E. Barbin‡ and Luis G. P. Meloni* "Software Defined Radio on Digital Communications: a New Teaching Tool" FEEC – School of Electrical and Computer Engineering UNICAMP – State University of Campinas Campinas, SP – Brazil DRC – Convergent Networks Department, CPqD – Research and Development Center Campinas, SP – Brazil, EPUSP – Polytechnic School, USP – University of São Paulo, São Paulo, SP – Brazil.
- [4] Boonyarit Uengtrakul1, Dahmmaet Bunnjaweht2, Dept. of Electrical and Computer Engineering Thammasat University, Pathumthani 12120, Thailand "A Cost Efficient Software Defined Radio Receiver for Demonstrating Concepts in Communication and Signal Processing using Python and RTL-SDR"
- [5] RTL-SDR wiki. Available <http://sdr.osmocom.org/trac/wiki/rtl-sdr>
- [6] Boonyarit Uengtrakul1, Dahmmaet Bunnjaweht2, Dept. of Electrical and Computer Engineering Thammasat University, Pathumthani 12120, Thailand "A Cost Efficient Software Defined Radio Receiver for Demonstrating Concepts in Communication and Signal Processing using Python and RTL-SDR"
- [7] RTL-SDR Block Diagram [online]. Available http://aaronscher.com/wireless_com/SDR/rtl_sdr_info.html
- [8] RTL_POWER Scripting [online]. Available <http://kmkeen.com/rtl-power/>
- [9] Gqrx SDR Software [online]. Available <http://gqrx.dk/>
- [10] "What is Python" [online]. Available <https://docs.python.org/3/faq/general.html#what-is-python>.
- [11] "Python Heatmap Viewer" [online]. Available <https://github.com/keenerd/rtl-sdrmisc/blob/master/heatmap/heatmap.py>