ANALYSIS OF MODULATION PARAMETERS OF HIGH FREQUENCY DIGITAL MODULATION SIGNAL

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To my mother, Rohayah Mustaffa;
for her encouragement and support

To my wife, Mazarina Azlin Mustaffa;
To my children, Batrisyiah Syahirah and Hardy Danish Danial;
for their love

ABSTRACT

High Frequency (HF) radio communication has grown both in the business and private sectors such as for voice, data communication and remote computer accessing from merely sending Morse code. It is still widely used all over the world along with satellite communication. Spectrum surveillance and monitoring is useful in confirmation to the HF frequency allocation because of it scarce resource shared by many users and as part of the radio surveillance it is important to monitor data communication over the air space. The estimation of modulation parameters allows the signal to be classified and to recover the binary information from the signal. This paper reports the study of time-frequency transform applied to HF data signals and the estimation of the signal parameters. The method described is the Short Time Frequency Transform (STFT) also known as the spectrogram develops from standard Fourier Transform techniques to handle non-stationary data. This method is the most basic of time-frequency distributions. The signal under test is a simulated signal either with or without the present of random white noise signal. The result shows an approximation of the frequency, type of modulation and bit rate presence within the signal under test.

ABSTRAK

Komunikasi radio berfrekuensi tinggi (HF) telah berkembang di dalam sector swata dan perniagaan untuk perhubungan suara, penghataran maklumat dan akses komputer jarak jauh dari hanya penghantaran Morse code. Ia masih lagi digunakan di serata dunia disamping penggunaan komunikasi satelit. Pemantauan dan pengawasan spektrum sangat penting dalam pengesahan pengguna julat radio HF kerana ia merupakan sumber yang digunaramai dan sebahagian dari pemantauan ini adalah penting untuk mengawal komunikasi di ruang udara kita. Penganggaran parameter modulasi membolehkan signal itu di klasifikasikan dan memperolehi maklumat binari dari isyarat tersebut. Penulisan ini melaporkan kajian tranformasi masa-frekuensi keatas isyarat HF dan penganggaran parameter isyarat tersebut. Tatacara yang dibincangkan ialah *Short Time Frequency Transform (STFT)* juga dipanggil *spectrogram* dihasilkan dari teknik *Fourier Transform* untuk isyarat tidak statik. Tatacara ini adalah yang paling asas untuk penyebaran masa-frekuensi. Isyarat yang digunakan untuk ujian ini adalah isyarat simulasi dengan atau tanpa isyarat *white noise*. Hasil ujian ini merupakan anggaran frekuensi, jenis modulasi dan kadar bit hadir dalam isyarat yang diuji.

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B	-	Window mainlobe width.
f_0	-	Fundamental frequency.
f_1	-	Upper frequency.
f_2	-	Lower frequency.
f_{max}	-	Highest FFT frequency.
f_s	-	Sampling frequency.
k	-	Discrete frequency index.
M	-	Window frame length.
N	-	Number of samples.
$P(t,f)$	-	Joint time frequency.
S	-	Number of samples advanced between frames.
W^n	-	Complex variable.
$x_m(n)$	-	Windowed x(n).
x(n)	-	Discrete time functions.
$x(t)$	-	Time functions.
$w(t)$	-	Time varying signal.
$\rho_x(n,k)$	-	Discrete joint time frequency.
$\varphi(t)$	-	The phase.
$\varphi'(t)$	-	First derivative of phase.

CHAPTER 1

INTRODUCTION

The radio frequency spectrum such as High Frequency (HF) spectrum is still widely used all over the world along with satellite communication. HF radio band refers to the spectrum between 3 to 30 MHz. From the laboratory, electronic communication grew first to military, and then civil use, such as Morse Code and later a nation-wide telegraph system. Throughout the 20th century, the use of electronic communication has grown in both the business and private sectors for voice and, more recently, data communication; radios, telephones, televisions, and remote accessing of computers are just some of the products that have resulted. Today, HF communications is done digitally to minimized probability of interception (POI) and avoid detection. In addition it also provides high security on transmitted information as far as confidentiality and authentication is concerned. Spectrum surveillance and monitoring is useful in confirmation to the HF frequency allocation because of it scarce resource shared by many users and as part of the radio surveillance it is important to monitor data communication over the air space. The estimation of modulation parameters allows the signal to be classified and to recover the binary information from the signal.

1.1 Objective

This research is focused on parameters determination of a data communication over HF radio transmission with objective to analyse a HF digital modulation signal using software system design with Matlab programming aimed at the development of algorithm that is able to carry out the following task:

i. Estimation of sub-carrier frequency;
ii. Identification of modulation type;
iii. Estimation of data bit rate.

1.2 Scope of Work

The scope of work for this study is to estimate the parameters of data signal transmitted over HF frequency spectrum in either frequency shift keying (FSK) or amplitude shift keying (ASK) modulation methods. The signal is sampled at 8000Hz giving a detected sub-carrier frequency from 0 to 4000 -Hz. The tool employed in this study is MATLAB version 6.1 programming software with it Graphical User Interface Development Environment (GUIDE) for user interface. The output of the analysis will be the graphical representation of time-frequency distribution (TFD), instantaneous frequency representation and frequency spectrum along with the estimated parameters. The signal under observation is a simulated signal either with or without the present of random white noise.

1.3 Problem Statement

The radio frequency spectrum such as the HF spectrum is a scarce resource shared by service providers and managed by regulatory bodies. Conformance to the radio frequency allocations can be verified using radio monitoring systems. In addition, radio monitoring systems can assist in the detection, analysis and classification of radio transmissions (Ahmad Zuri Sha'ameri,2000). Managing and monitoring the radio spectrum involving the detection of signal frequency, modulation type and bit rate is a part of radio surveillance. A capability to monitor signal transmission by using any available radio receiver with PC based software is an advantage for any regulatory bodies that control and coordinate radio spectrum in the failure of their state-of-the-art equipment.

1.4 Research Methodology

The methodology of the study is establish first with a literature review on HF spectrum monitoring (Ahmad Zuri Sha'ameri,2000), time-frequency distribution of audio signal (Matthew Van Dyke Kotvis,1997) and time-frequency representation of time-varying signals (National Instrument Corporation,1995). These literature reviews gives a fundamental knowledge on how to start the analysis on the HF modulation parameters

Having the fundamental knowledge then it is decided the analysis will be focused on the data communication using Windowed Fourier Transform also known as spectrogram (Anna H.Pryor, Marianne Mosher and David G.Lewicki,2001). The spectrogram although the most basic of time frequency distribution calculation gives an enough information to estimates the required parameters.

All computations are done using the MATLAB version 6.1 programming software. The analyse signal is a simulated signal with and without the present of Gaussian noise in lieu with International Telecommunication Union-Radio (ITU-R) recommendation in place of actual signal. After the program is working it can be used for data analysis and a report is written.

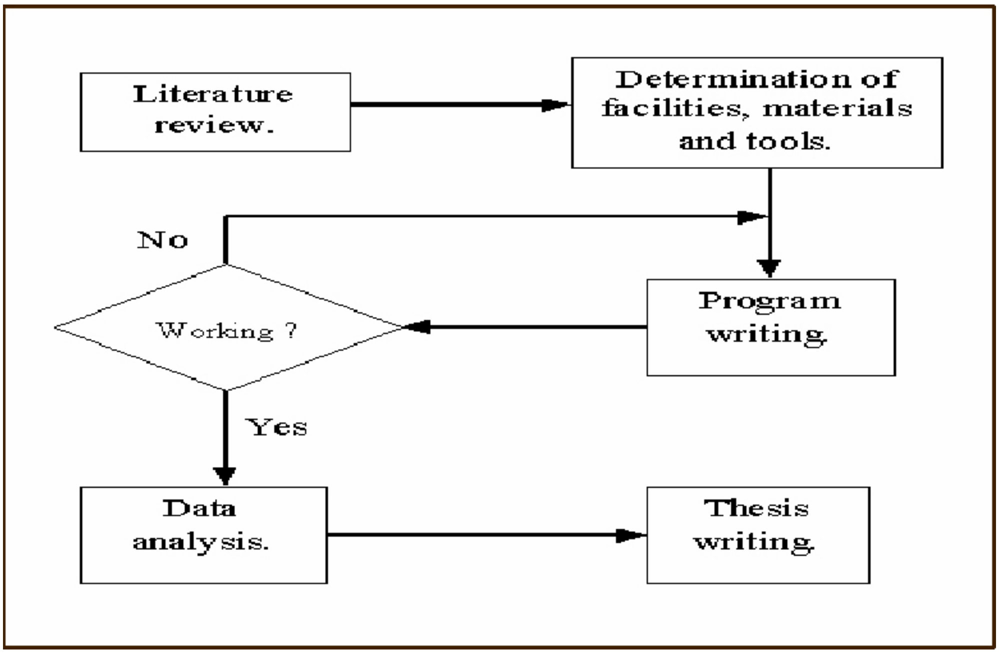

Figure 1.1: Research Methodology flow.

REFERENCES

Ahmad Zuri Sha'ameri. (2000) *Surveillance and Monitoring Of the HF Radio Frequency Spectrum*. University Teknologi Malaysia.

Matthew Van Dyke Kotvis. (1997). *An Adaptive Time-Frequency Distribution with Applications for Audio Signal Separation.* Master Thesis. University of Miami.

National Instrument Corporation. (1995). *Joint Time Frequency Representation for Real-Time Detection of Time Varying Signals.* Los Alamos National Laboratory; Application Note 067.

Anna H.Pryor, Marianne Mosher and David G.Lewicki. (2001). The Application of Time-Frequency Method to HUMS. *American Helicopter Society's 57th Annual Forum.* May 9-11, 2001. Washington DC; American Helicopter Society.

Proakis, J.G. (1995) *Digital Communications*, McGraw-Hill, New York.

Johnson, E.J., Desourdis and R.I., Jr. (1997). *Advanced High Frequency Communications*, Artech House, London.

Kay, S.M. (1998). *Modern Spectral Estimation : Theory and Application,* Prentice-Hall, New Jersey.

Baastians, M.J., (1995). "On The Sliding Window Representation In Digital Signal Processing", *Ieee Trans. Acoust. Speech, And Signal Processing,* Vol. 33, No. 4, August 1985, Pp 868-873.

Daubechies, I., (1990). "The Wavelet Transform : A Method For Time-Frequency Localization", Haykin (Editor), *Advances In Spectrum Estimation And Array Processing*, Vol. 1 Of 2, Prentice-Hall, New Jersey, 1990.

Clay Lester. (2001). *The Beginner's Handbook of Amateur Radio*. 4th ed. New York. McGraw-Hill. 2001.

Behrouz A.Forouzan. (2001). *Data Communication and Networking.* 2nd ed. New York. McGraw-Hill. 2001.

Kaiser, Gerald. (1994). *A Friendly Guide to Wavelets*. Birkhauser, Boston, 1994.

Ewald, D. and Bollinger, J.G., (2000). *Theory and Application of Fast Fourier Transforms for Data Analysis*, Design Engr. Laboratories, Univ. of Wisconsin, Madison.

Charles L.Philips and John M.Parr. (2003). *Signal, System and Transformation*. 3rd ed. Upper Saddle River. Prentice Hall.

Allan, J.B. and Rabiner, L.R. (1977). *A Unified Approach to Short Time Fourier Analysis and Synthesis*. Proc. IEEE, vol. 65, pp. 1558-1564

Serra, X. (1989). *A System for Sound Analysis/Transformation/Synthesis Based on a Deterministic Plus Stochastic Decomposition*. PhD Dissertation, Department of Music, Stanford University.

Mayor, Jonathan L. (1992). *The Radio Amateur's Digital Communications Handbook*. Blue Ridge Summit, Pa.: TAB Books.