PERFORMANCE ANALYSIS OF DIFFERENTIAL PHASE MODULATION FOR HF COMMUNICATION

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Dedicated to my beloved Mak and Abah:

Hj. Mohd Saad b. Hj. Kasim and Hjh. Siti Jeliha bt. Hj. Zakaria

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ABSTRACT

Data transmission using HF spectrum (3-30 MHz) is widely used due to its ability in providing long distance communications at low cost. Due to multipath fading problems in HF channels, the maximum symbol rate of data transmission is limited to 100 baud per second. Differential multiple phase modulation techniques can be used to increase the transmission rate without changing the baud rate. Advanced digital modulation techniques based on PSK is used due to its reliability in providing lower error rate compared to other modulation techniques, such as modulation based on FSK. Unlike coherent detection, phase synchronization is not critical for the differential detection, and implementation can be made simpler in differential multiple phase modulations. For this study, the BER and PER performance of DPSK, DQPSK, D8PSK and D16PSK modulation techniques are presented. The performance evaluation for each modulation are investigated in additive white Gaussian noise environment and random phase delay is included that is based on uniform distribution. In general, the BER and PER performance for differential multiple phase detection decrease for every doubling of phases, but the main advantage is the reliability in data transmission in achieving higher transmission rate.

ABSTRAK

Penghantaran data melalui spektrum HF (3-30 MHz) digunakan secara meluas kerana keberkesanannya di dalam sistem komunikasi jarak jauh dengan kos yang rendah. Walaubagaimanapun, saluran HF terdedah kepada masalah pemudaran *multipath*, yang menghadkan kadar maksimum penghantaran data kepada 100 *baud* per saat. Bagi mengatasi masalah ini, pemodulatan pembezaan berbilang fasa boleh digunakan, di mana kadar penghantaran data ditingkatkan tanpa mengubah kadar simbol data. Pemodulatan digital berdasarkan fasa, PSK dipilih kerana kebolehannya memberikan BER yang lebih rendah berbanding kaedah lain, seperti pemodulatan frekuensi, FSK. Tidak seperti pengesanan secara koheren, pengesanan secara perbezaan tidak dipengaruhi oleh lengah fasa, dan perlaksanaannya menjadi lebih ringkas. Di dalam kajian ini, prestasi BER dan PER bagi DPSK, DQPSK, D8PSK dan D16PSK di analisis di dalam persekitaran hingar putih Gaussian, manakala lengah fasa secara rawak dikenakan pada isyarat mengikut taburan normal. Secara umumnya, nilai BER dan PER merosot bagi setiap peningkatan gandaan fasa dalam pemodulatan, tetapi kelebihannya adalah keberkesanannya meningkatkan kadar penghantaran data.

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BER	-	Bit Error Rate
DPSK	-	Differential Phase Shift Keying
DQPSK	-	Differential Quadrature Phase Shift Keying
D8PSK	-	Differential 8-Phase Shift Keying
D16PSK	-	Differential 16-Phase Shift Keying
FSK	-	Frequency Shift Keying
HF	-	High Frequency
PER	-	Packet Error Rate
PSK	-	Phase Shift Keying
SNR	-	Signal to Noise Ratio

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CHAPTER I

INTRODUCTION

1.1 Introduction

Ionospheric propagation is responsible for the ability to do broadcasting and communications. The long distance transmission is carried out on the HF spectrum (3-30 MHz) using skywave propagation, while for the short distance transmission, the groundwave propagation will be used [Goodman, 1992]. Nowadays, the HF communication system is widely used, not only for the tactical and strategic military purposes, but also by the commercial world, amateur radios, maritime and aeronautical operators.

The advantages of this type of communication arise from its relative simplicity, its ability to provide communication over thousand of miles and its moderate cost per circuit mile. HF communication involves minimum infrastructure and inexpensive maintenance compared to other technology such as satellite communication [Abdullah-Husni et al, 2003].

Due to variability of ionosphere, the HF signal is subjected to multipath fading phenomenon, which limits the data transmission rate to 100 baud per second [Goodman, 1992]. In order to overcome this problem, the advanced modulation techniques can be used to ensure the reliability in data transmission. Thus, the focus of this study is to design a HF communication system that can improve the reliability in data transmission using differential multiple phase modulation techniques.

1.2 Purposes Of The Study

The purpose of this study was to design and simulate a HF communication system that can increase data transfer rate that is limited by using HF channel using advanced modulation techniques specifically in differential multiple phase modulations. The performances of the techniques are analyzed in term of the bit error rate and packet error rate of the modulation. Differential detection is used to overcome phase synchronization error in coherent detection.

1.3 Scope Of Work

This study was focused on differential multiple phase digital modulation, which is important to design a system that can increase data transfer rate that is limited by using the HF transmission channel. The modulation techniques used are DPSK, DQPSK, D8PSK and D16PSK.

System was designed to process within the voice band frequency and not on radio band frequency. Sampling frequency used is 8000 Hz and the carrier frequency is 1000 Hz. The bandwidth of the signal is 4000 Hz.

Data format used is PACTOR, containing 8 characters or 64 bits of data and 16 bits for error control in a packet for 100 baud data transmission rate. The system was designed to test in a present of additive white Gaussian noise and random phase delay in received signals.

1.4 Definitions of Terms

For the purpose of this study, the following operational definitions are used:

BER	Bit error rate – number of error present within the period of data transmission
DPSK	Differential phase shift keying
DQPSK	Differential Quadrature phase shift keying
D8PSK	Differential 8-phase shift keying
D16PSK	Differential 16-phase shift keying
FSK	Frequency shift keying
HF	High frequency band channel
PER	Packet error rate – number of packet with at least an error presents
PSK	Phase shift keying
SNR	Ratio of signal power to noise power

1.5 Problem Statements

In HF communication system, the variability of ionosphere results multipath fading phenomenon. This phenomenon gives several affects in the communication, which are frequency selective fading and time selective fading [Goodman, 1992].

Frequency selective fading problems will cause for inter symbol interference (ISI). Due to this problem, the maximum data transmission rate is limited to 100 baud per second [Goodman, 1992][Willink et al, 1996]. By limiting the data transmission rate to 100 baud per second, inter symbol interference (ISI) problem can be avoided. As a solution, to increase the data transmission rate without changing or increasing the baud rate, the differential multiple phase modulation can be used.

1.6 Research Methodology

There are several approaches taken in order to achieve the objective of this study, which are:

1. Literature of review on HF communication system for understanding the concept and problem that occur in this particular type of communication.
2. Understanding the basic theory on digital signal processing and digital communication system to find ways on solving research problems.
3. Designing differential multiple PSK system which are DPSK, DQPSK, D8PSK and D16PSK.
4. Programming in MATLAB for performance analysis purposes.

5. Data analysis and simulation of the detection using MATLAB to analyze the performance of modulation techniques in term of BER and PER.
6. Calculation and performance comparison between theory and simulation.
7. Thesis and report writing.

1.7 Organization Of Thesis

This thesis is divided into six chapters. The first chapter contains an overview of this project. Some explanations about the literature and recent development in HF were covered in chapter 2. Chapter 3 describes the theory in HF digital communication. The design of differential multiple phase modulations were described in chapter 4. Chapter 5 presents the analysis of results. This thesis ends with the conclusion and suggestions for further research.

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