DESIGN AND SIMULATION OF DIGITAL AUDIO BROADCASTING TRANSMITTER

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For my beloved family, supervisor, lecturers and friends

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ABSTRACT

Digital Audio Broadcasting (DAB) is an audio broadcasting technology which is becoming more important nowadays. This system will replace existing analogue audio broadcasting systems which are Amplitude Modulation (AM) and Frequency Modulation (FM) system while offering few advantages compared to the current system nowadays. The objectives of this project is to design a transmitter of Digital Audio Broadcasting (DAB) system where Differential Quadrature Phase Shift Keying (DQPSK) modulation technique will be implemented along with Orthogonal Frequency Division Multiplexer (OFDM) to overcome Intersymbol Interference (ISI) that always occur in digital audio transmission. This transmitter system will be designed and simulated using Matlab software. This transmitter will be simulated with the receiver system to ensure that it will operate in accordance to the project requirement. The results also will be compared to the analogue system to highlight the advantages of this system.

ABSTRAK

Sistem penyiaran audio digital adalah satu sistem penyiaran untuk audio yang kian berkembang pada masa ini. Sistem ini akan menggantikan sistem penyiaran audio analog yang sedia ada iaitu sistem AM dan FM disamping menawarkan beberapa kelebihan berbanding sistem yang digunakan sekarang. Tujuan projek ini adalah untuk mereka satu sistem pemancar untuk sistem penyiaran audio digital dimana teknik modulasi 'Differential Quadrature Phase Shift Keying' (DQPSK) akan digunakan disamping 'Orthogonal Frequency Division Multiplexer' (OFDM) untuk mengatasi 'Intersymbol Interference' (ISI) yang biasa terjadi dalam penghantaran isyarat secara digital. Sistem pemancar ini akan dibangunkan menggunakan perisian Matlab dan seterusya akan disimulasikan menggunakan perisian yang sama. Sistem pemancar ini akan disimulasikan bersama sistem penerima yang juga dibangunkan untuk memastikan ia berfungsi seperti yang dikehendaki. Seterusnya keputusan yang diperolehi akan dibandingkan dengan sistem analog yang digunakan pada masa ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NO.	TITLE	PAGE

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Audio broadcasting technology has started for a long time and it has brought major impact to the telecommunication field around the world. The word broadcasting itself refers to distribute audio or video to an audience. In a broadcasting system, the signal will be converted in a transmitter before being transmitted through a suitable transmission medium. Then the signal will be detected using a receiver which will convert the signal back to its original form. Until now, we are using an analogue system to broadcast an audio signal. Correspond to the growth of technology, digital system has been invented to enhance the quality and performance of the broadcasting system. This project will focus on the design of digital radio transmitter for digital audio broadcasting (DAB). The design and simulation process will be made using Matlab environment.

1.2 OBJECTIVE

The purpose of this project is to design and simulate a digital audio transmitter for Digital Audio Broadcasting (DAB). This can be done by employing Differential Quadrature Phase Shift Keying (DQPSK) and using Orthogonal Frequency Division Multiplexer (OFDM). The modulation scheme which is an incoherent modulation scheme also incorporates a form of Gray coding. OFDM is modulation technique especially suitable for wireless communication due to its resistance to intersymbol interference (ISI). The whole system will be developed using Matlab simulation environment where a set of source codes must be program for the design of this transmitter. This project should be useful as Digital Audio Broadcasting will be implemented to replace analogue radio system in coming years.

Figure 1.2.1: Example of Digital Radio

1.3 PROBLEM STATEMENTS

Digital Audio Broadcasting service was first used in United Kingdom in 1995 and the receiver is begun to sell in 1999. Until now over 600 million peoples were under the coverage of DAB broadcast.

The first commercial Digital Audio Broadcasting service in Asia Pacific was launched in November 1999 in Singapore by MediaCorp Radio Singapore. Since that, many countries in Asia Pacific region have implemented Digital Audio Broadcasting for their broadcasting service [1].

Compared to analogue audio broadcasting, this system has better performance in its transmission efficiency, usability and sound quality. This system also has a wider bandwidth so it can transmit more data at one time. Furthermore, this system is quite flexible so it can be change instantaneously based on the needs of the content provider.

However, until today, Digital Audio Broadcasting is not fully implemented in Malaysia. In order to use this service in Malaysia, a DAB receiver will be needed and in order to simulate the transmitted DAB signal, a digital transmitter must be designed.

1.4 SCOPES OF WORK

There are some parts of this project that must be done in order to complete this project. Firstly, the basic of Digital Audio Broadcasting must be studied, its modulation technique and its transmitter circuit briefly. Then the transmitter will be designed from module by module using Matlab software. Those modules that need to be studied are the Orthogonal Frequency Division Multiplexer (OFDM) modulator, the Differential Quadrature Phase Shift Keying (DQPSK) and Gray coding. Then, those modules will be combined to make a complete Digital Audio Broadcasting transmitter. After complete integration of the module, then the transmitter will be simulated and the produced signal will be transmitted to the receiver part. The result produced then will be analyzed to determine the efficiency of the system.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Digital Audio Broadcasting differs from analogue broadcasting system that is used nowadays in many aspects. Besides offering many advantages compared to existing analogue broadcasting system, digital audio broadcasting uses more efficient modulating technique and the signal then will be multiplexed to overcome intersymbol interference which always occurs during digital signal transmission. A coding technique also will be used to enhance the performance of the system of digital communication network. The desired signal to be transmitted will be modulate with a high frequency carrier before being multiplexed. Then the signal will be transmit in a single frequency network (SFN). Signal that is transmitted through Digital Audio Broadcasting must use digital radio receiver to receive the signal [1].

2.2 BACKGROUND STUDY

Since the early days of broadcasting, analogue systems have been used to carry programmes from the studios to the listeners. Now, due to the growing number of broadcasters and programme services, the frequency bands allocated to AM and FM radio in many regions of the world are full. The resulting congestion in the radio spectrum has led to a decline in reception quality and is a real constraint to further growth. Furthermore, in densely populated areas, FM reception on car radios and portables can be very poor. This is due to the effect of severe multipath propagation caused by signal reflections and shadowing due to high buildings [2].

Digital transmission technology can offer much improved coverage and availability. It is expected to replace analogue transmissions in many areas, but as digital systems are incompatible with current AM and FM broadcasting systems, new receivers will be needed [2].

In basic form, digital radio is an application of the technology in which sound is processed and transmitted as a stream of binary digits. The principle of using digital technology for audio transmission is not new, but early systems used for terrestrial television sound (such as NICAM 728) need considerable bandwidth and use the radio frequency spectrum inefficiently, by comparison with today's digital systems [2].

The development of digital radio has been helped by the rapid progress that has been made in digital coding techniques used in radio frequency and audio systems. This has led to improved spectrum efficiency, more channel capacity, or a combination of these benefits. Digital compression techniques used in audio systems have improved sound quality at low bit rates to the extent that radio broadcasts can be made on location and then transmitted to the broadcaster's production studios over telephone circuits in high quality [2].

Ideally, to reach the widest range of listeners, a genuinely universal digital radio system should be capable of being transmitted via terrestrial, satellite and cable systems [2].

Digital Audio Broadcasting (DAB) has been under development since 1981 at the Institut für Rundfunktechnik (IRT), Germany. In 1985 the first DAB demonstrations were held at the WARC-ORB in Geneva and in 1988 the first DAB transmissions were made in Germany. Later DAB (or Eureka-147) was developed as a research project for the European Union (Eureka project number EU147), which started in 1987 on initiative by a consortium formed in 1986. DAB was the first standard based on orthogonal frequency division multiplexing (OFDM) modulation technique, which since then has become one of the most popular transmission schemes for modern wideband digital communication systems [3].

The UK was the first country to receive a wide range of radio stations via DAB. Commercial DAB receivers began to be sold in 1999 and over 50 commercial and BBC services were available in London by 2001. By 2006, 500 million people worldwide were in the coverage area of DAB broadcasts, although by this time sales had only taken off in the UK and Denmark. In 2006 there are approximately 1,000 DAB stations in operation worldwide [3] [4].

The services of Digital Audio Broadcasting will replace the existing analogue system due to many advantages that is offered by this service. Some of the advantages are high quality digital audio services. The sound quality offered by DAB is superior compared to analogue broadcasting system. The reception condition of DAB is perfect where interference and multipath are eliminated while in car. It also covers wide area with an even, uninterrupted signal. In a full service of DAB, drivers can stay tuned to the same station while driving across a country without changing or altering frequency. The transmission efficiency of this service is also greater than analogue system where DAB provide lower transmission costs for a wider range of programme material to the broadcaster. This is because, using the same frequency, more programme and data can be broadcast compared to analogue system. DAB also provides greater frequency efficiency as it is designed as Single Frequency Network which saves lot of transmission frequencies [5].

DAB also offers wide range of value added service which means that both music and data can be received using the same receiver. Besides broadcast radio main services, DAB also able to transmit program associated data. This means that receiver can display information more detail that Radio Data Service (RDS) such as future broadcast, weather forecast or CD cover images through a small screen attached to the receiver. DAB also make advertising using radio will be more interesting [5].

The other advantages of Digital Audio Broadcasting (DAB) are the level of standardization is rather advance and the various recent international standards and related documents are introduced and referred to for easy access for the reader seeking technical details. The system layout of (DAB) is universal which will allow applications for all known transmission media and receiving situations. With DAB unique system design, it service will be available on manly on terrestrial but also suited for cable and satellite networks. This universal system layout also makes it possible to access DAB services on a wide range of receiving equipment [5].

The DAB contains more flexible multiplex configuration which allows the configuration to be changed according to the needs of the content providers. The bit rate also flexible and can be change according to the content of the programme [5].

2.3 DAB TRANSMITTER

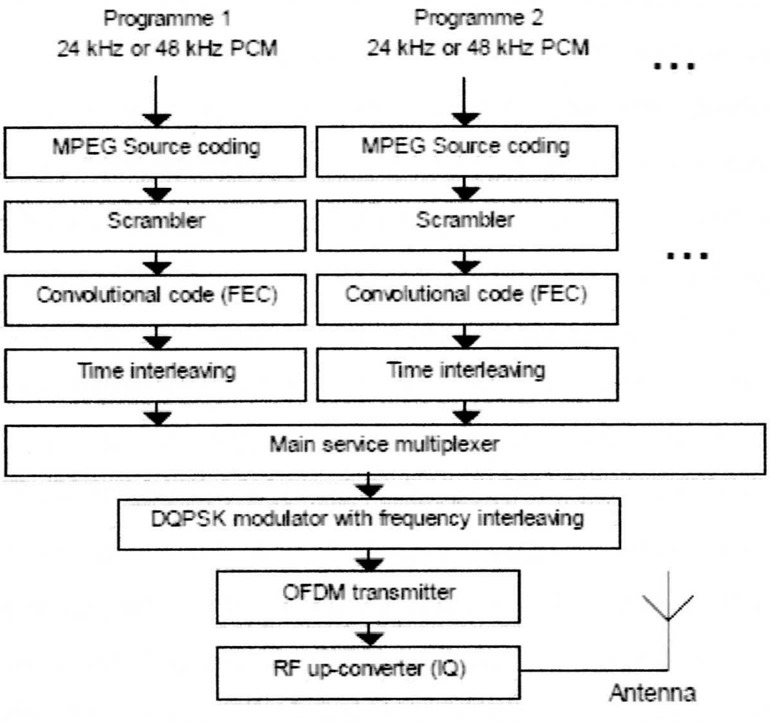

Figure 2.3.1: Block diagram of a DAB transmitter

From the block diagram of DAB transmitter, we can see that the operation of DAB transmitter which multiplexes one or more signal then it will be transmitted in OFDM form. The overall DAB transmission system can be broken down into a number of sub-blocks as shown above. The audio signal will be encoded and then scrambled. Forward error correction will be applied to the scrambled bit-stream by employing punctured convolutional codes. The bit-stream is sent through a time interleaver before it is multiplexed with the other programmes to form an ensemble. The ensemble bit-stream is fragmented into individual OFDM symbols, which are obtained by differential QPSK modulation of the subcarriers and basically an inverse Fourier transform (IFFT) operation within the OFDM transmitter [6].

In the receiver the corresponding inverse operations have to be carried out. The information bit-stream is divided into a number of lower rate bit-streams in OFDM, which are individually modulated onto orthogonal sub-carriers. To achieve orthogonality, sub-carriers are spaced in frequency by the inverse of the symbol duration, theoretically resulting in zero inter-carrier interference. Although the sinc(f) responses mutually overlap, they go through zero at centre frequencies of all other sub-carriers, giving a spectrum efficiency of up to 2 (bit/s)/Hz for QPSK modulation of each sub-carrier [7]. Orthogonal sub-carriers can be realized with the IFFT algorithm, which can be readily integrated into hardware. Each sub-carrier is modulated with differential QPSK, which maps the incoming bits to complex symbols *G(k)* for each sub-carrier *k*. The last complex output values of the IFFT are copied to the front of the symbol to add the guard interval (cyclic prefix). It must be noticed that the complex symbols are frequency interleaved before being fed into the IFFT. Corresponding inverse functions are applied at the receiver. The clock of the receiver has to be synchronized exactly to the incoming signal, whereas the guard interval between the symbols is discarded. Then the FFT is applied, the individual carriers are DQPSK demodulated and the original bit-stream is regenerated [6].

The relatively high ensemble bandwidth of about 1.5 MHz gives good frequency diversity, since frequencies are not affected in the same way by fading. Adjacent bits within the MPEG bit-stream are made statistically independent with respect to bit errors by employing frequency and time interleaving, leading to good performance of the convolutional decoder (Viterbi) [6].

2.4 DAB TRANSMISSION MODES

Technically, the DAB transmission system can be used in all VHF and UHF broadcasting frequency bands between 30 and 3000 MHz and four specific modes for typical applications have been defined.

Table 2.4.1: DAB Transmission Modes

Mode	Total Symbol Duration	Main Application
I	1246μs	Terrestrial DAB, large coverage areas, VHF (Band III)
II	312μs	Terrestrial DAB, small to medium coverage areas, UHF (L-Band)
III	156μs	Satellite DAB, no long echoes, UHF (L-Band)
IV	623μs	For Canada, between mode I and II

The total symbol duration consists of the principal symbol period and a guard interval, which prevents the echo of the previous symbol from interfering with the current symbol. By doing so, inter-symbol interference (ISI) is reduced to almost zero as long as the echoes from the various transmitters and propagation paths do not substantially exceed the guard interval. The maximum permissible propagation path difference Δd in meters can be calculated from the guard interval T_{guard} and the propagation speed *vc*, as below:

$$\Delta d = T_{guard} \,.\, vc \qquad (2.4.1)$$

All modes have an ensemble bandwidth of exactly 1.536 MHz, but since the symbol duration and therefore the carrier spacing (inverse of the useful symbol duration) vary, the number of carriers that can be accommodated within the ensemble bandwidth differs from one mode to another [6].