DESIGN OF GRAPHICAL USER INTERFACE FOR MULTIUSER SAC-OCDMA PERFORMANCE ANALYSIS

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ABSTRACT

The transmission of data by multiple users simultaneously using various multiple access techniques over fibre optic communication has been studied in several literatures. It provides high data rates and leads to high total throughputs while taking advantage of high speed in optic fibre. In multiuser transmission using OCDMA, many codewords are sent simultaneously over the channel as a result of many active users and this can cause multi-user access interference between users. Spectral-amplitude-coding (SAC) OCDMA is used to cancel the effect of multiuser access interference using code sequence with in-phase cross correlation. Several OCDMA based on SAC OCDMA codes such as. Quadratic Congruence (QC), Extended Quadratic Congruence (EQC) and Modified Quadratic Congruence (MQC) proportion were investigated further and implemented. Furthermore, in the SAC-OCDMA, appropriate detection technique is required to reduce the multi-user access interference between users and extraction of user data. Three detection technique were considered AND, modified-AND and single photodiode detection (SPD) technique. In this project, the graphical user interface (GUI) was developed for multi-user OCDMA performance analysis using the matlab platform. This allowed for comparison in terms of length of code, data rate for multiple users.In addition , the performance of the decoder which is implemented using fiber Bragg gratings (FBGs) for the three detection techniques using numerical analysis have been developed for the GUI. The numerical analysis is based on the SNR and BER for the system in the presence of thermal noise, shot noise and phase induced intensity noise. Finally, The developed is GUI used to compare the performance of the QC, EQC and MQC codes, AND, modified-AND and SPD detection techniques. Result shows that MQC outperforms EQ and EQC codes when many active users transmitting. The SPD detection technique when modified double weight (MDW) code was used. has a better BER and SNR compared to the modified-AND and AND detection technique.

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LIST OF ABBREVIATION

BER	-	Bit error rate
CDMA	-	Code Division Multiple Access
DS-CDMA	-	Direct-sequence CDMA
FBGs	-	Fiber Bragg gratings
FH-CDMA	-	Frequency-hopping CDMA
GUI	-	Graphical user interface
MAI	-	Multiple access interference
MUI	-	Multiple user interference
OOC	-	Optical orthogonal code
PIIN	-	Phase induced intensity noise
PSD	-	Power spectral density
P.U	-	Power Unit
QC	-	Quadratic congruence
SAC-OCDMA	-	Spectral-amplitude-coding OCDMA
SNR	-	Signal to noise ratio
WDMA	-	Wavelength Division Multiple Access
Gbps	-	Gigabits per second

LIST OF SYMBOLS

e - Electron’s charge

C_m - The code sequence for the m-th user

I - Average photocurrent,

B - Noise-equivalent electrical bandwidth of the receiver,

τ_c - Coherence time of source,

K_b - Boltzmann’s constant,

p - Prime number

R_L - Receiver load resistor.

T - Period of data signal (seconds)

Tc - Chip time (seconds)

T_n - Absolute receiver noise temperature

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The transmission of data by multiple users simultaneously using various multiple access techniques over fibre optic communication has been studied in several literatures. This provides high data rates and leads to high total throughputs while taking advantage of high speed in optic fibre. This is particularly useful in meeting the bandwidth demand in future information networks by efficiently utilizing the available optical bandwidth.

The major multiple access schemes include Wavelength Division Multiple Access (WDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA). The use of CDMA in optical fibre offers interesting features for LAN compared to TDMA and WDMA. OCDMA is considered a better multiple access scheme because it does not require time management or frequency management of all transmitting nodes of users. Furthermore, it can operate asynchronously without centralized control which amounts to low latency. OCDMA can also benefit from high multiplexing gains since dedicated time or wavelength slots do not have to be allocated to users. In addition it allows flexible network design since bit error rate (BER) depends on the number of active users. [1].

In OCDMA each user is assigned one or more signature sequences called codewords, which are subsets of a type of optical orthogonal code (OOC). The channel input/output consists of the superposition of several users' code words and at the receiver end an optical correlator extracts the information. Multiple user codewords are combined together and sent over the channel as shown in Figure. 1.1. A decoder for each user is used at the receiver end to compare the incoming sequence with stored copies of the codewords in order to extract the information bits. Optical orthogonal codes (OOC) has been considered suitable for OCDMA and was first introduced by [2]. The use of OOC codes allows large number of asynchronous users to transmit information efficiently and reliably. Fundamentals of OOC are discussed in Chapter 2.

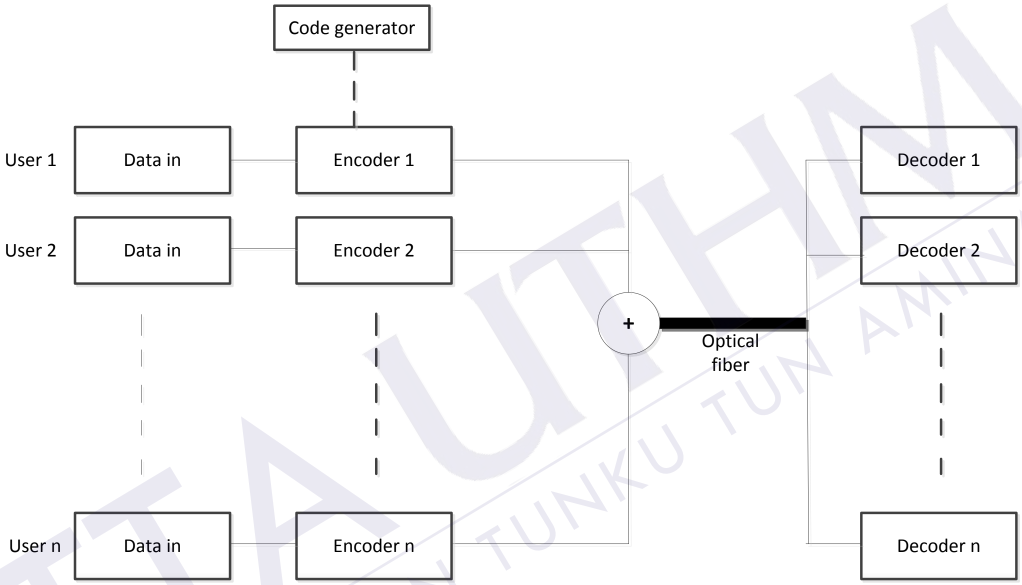

Figure 1.1: Multiuser OCDMA System with n number of users [1].

In this research, fiber Bragg gratings (FBGs) is used for implementation of encoder-decoder for OCDMA. Spectral-amplitude-coding (SAC) OCDMA is used to cancel the effect of multiuser access interference using code sequence with in-phase cross correlation.

1.2 Problem statement

In multiuser transmission using OCDMA, many codewords are sent simultaneously over the channel as a result of many active users and this can cause interference between users. This is called multiple user interference (MUI) or multiple access interference (MAI). In addition, different coding scheme have been designed with different length of codes which affects the data rate when many active users are transmitting simultaneously. As the number of active users increase the performance of the system in terms of BER and SNR also varies. It was observed that the different OCDMA codes proposed by different author offers different performance level. These codes have been developed using different platforms for example Matlab but there is need for a simple and user friendly simulator that can be used to observe and analyse the performance of the different codes used in the encoding and decoding scheme. A simple simulation platform needs to be develop to compare the performance OCDMA codes based on data rate, bit error rate, length of coding scheme and signal to noise ratio when the number of active users transmitting varies.

1.3 Aims and Objectives

The primary aim of this project is to develop a Matlab graphical user interface system that allows for comparison of existing OCDMA encoding and detection scheme.

The objectives of this project are as follows:

1) To understand different OCDMA codes and detection scheme for multiusers.
2) To develop a graphic user interface GUI, for OCDMA multiuser system
3) To analyse the performance of multiusers in OCDMA system.

1.4 Scope and Limitation

This research is limited to simulation using Matlab and the scope of this work is outlined as follows:

1. Study and understand different OCDMA encoding and detection scheme

2. Simulate different OCDMA codes and detection scheme for multiple users
3. Compare simulated results in terms of BER, SNR, length of code and data
4. Design and develop a graphic user interface GUI with the following.

The system should satisfy the following requirments:-

1. To be able to select different number of users .
2. To be able to determine the data rate of different users.
3. To be able to compare to noise ratio (SNR) for different users.

1.4 Thesis outline

In **Chapter 2** the literature review is discussed. The basic theory of CDMA and OCDMA are presented. In addition, related works to OCDMA are compared. **Chapter 3** outlines the step taken in implementing this study. The research process and operational process were iterated. In **Chapter 4**, the results of the simulated work are analysed with explanations. Finally in **Chapter 5** conclusion and further work for this thesis is discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter we provide the background study on CDMA theory and optical CDMA codes. The different types of code selection and detection techniques are discussed.

2.2 Theory of Code Division Multiple Access (CDMA).

CDMA also known as radio-CDMA is a multiple channel access method in which several transmitters can send information simultaneously over a single communication channel. This has been employed in various radio communication technologies such as cdmaOne, CDMA2000 and WCDMA. Several users are able to share a band of frequency through spread-spectrum technology and a special coding scheme. The spread spectrum signal is generated using a fast pseudo-random code

Each transmitter is assigned an orthogonal code which is unique and different from each other. The Receiver uses these unique codes which are known prior to transmission in the detection process to separate wanted signal from unwanted signal. Some of the advantages of CDMA over other communication technologies like time division multiple access (TDMA) and frequency division multiple access (FDMA) are: high increase in data rate compared to TDMA due to simultaneous transmission of signals, better device management compared to FDMA since it allows users to transmit using same carrier frequency hence same transmitters are deployed in the system. In addition, The CDMA transmitters are simple and less expensive compared to TDMA and FDMA transmitters.

There are two basic types of CDMA, namely direct-sequence CDMA (DS-CDMA) and frequency-hopping CDMA (FH-CDMA) [1]. In DS-CDMA, users send a sequence of binary data when they want to transmit a ‘1’and they send a sequence of zeros when they want to transmit a ‘0’. The carrier frequency of the modulated signal is higher than that of the data signal and it depends on the CDMA code. In FH-CDMA, the spreading code contains different frequency components and the carrier frequency is always changing according to the code. This will increase the complexity of both transmitters and receivers. A transmitter should now consist of a broadband optical source and a multi-peak optical filter to create multi-wavelength optical output [3]. It has been seen that, the structure of transmitters should be as simple as possible.

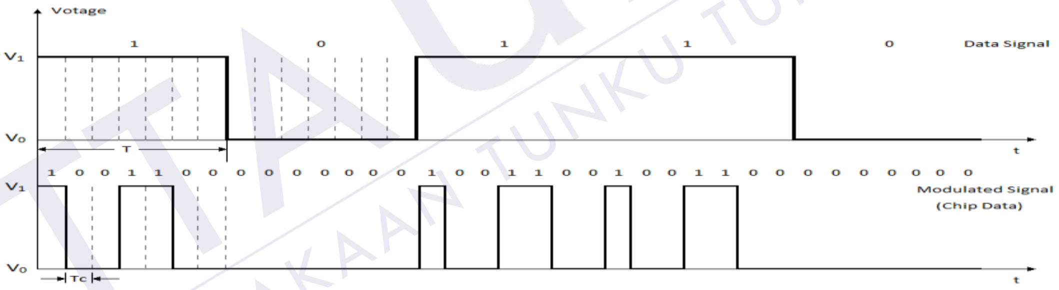

Figure 2.1: Principle of DS-CDMA [12].

Figure 2.1, above shows an example of DS-CDMA: a user wants to send data ‘10110’ and is assigned a CDMA code of ‘1001100’ in the network. From the above analysis, we could easily get the modulated signals of the user: ‘1001100 0000000 1001100 1001100 0000000’. It is noted that the small time slots in the graph are called chip and Tc is the chip duration. Therefore, the length of CDMA code (U) can be written as equation (2.1) below.

$$U = T / T_c \qquad (2.1)$$

Where U is the length of CDMA code, T is period of data signal and Tc is the chip duration.

2.3 Theory of Optical Code Division Multiple Access (OCDMA).

TDMA and WDMA are known traditional fibre optic communication schemes used to allocate bandwidth among several users. Unfortunately, when the numbers of users are large, these schemes pose significant drawbacks [4]. In TDMA, only one user can transmit at a time, hence the throughput of the system is limited by the product of number of users and their respective transmission rate. In addition, TDMA requires lot of coordination in allocating and granting request for time slots from users by the central node. This results to significant latency penalties. On the other hand, in WDMA system, each user transmits on a single wavelength of light using the peak speed of the network hardware. While WDMA can support high throughput, it is difficult to construct a WDMA system for a dynamic set of users because of significant amount of coordination among the nodes. Developing a WDMA network that supports dynamic user base, control channel and collision detection schemes would amount to waste of significant spectrum or bandwidth. Optical CDMA is seen as a good alternative to TDMA and WDMA because it does not require time or frequency (or wavelength) management system. In addition Optical CDMA offers significant gain in throughput by using multiplexing technique since time and frequency slots do not need to be allocated to each user. However, the limiting factor to CDMA is the bit error rate (BER) relationship to the number of users [5].

One of the basic requirements for optical CDMA is code orthogonality. Two categories of CDMA codes that have been identified are: ‘traditional’ CDMA codes and Optical Orthogonal Codes (OOCs). In OOCs the different codes that have been proposed are prime sequence (PS) [6], quadratic congruence (QC) codes [7], extended quadratic congruence (EQC) codes [8], modified quadratic congruence (MQC) codes [9],

2.4 Code Selection

In selecting a code, some factors needs to be considered. The most important is the cross-correlation function of a code due to the number of transmitters in the systems. The second factor is auto-correlation of the code. The cross-correlation makes it easy to reduce the interference due to other users and channel noise and auto-correlation enables the effective detection of the desired signal. In-phase cross-correlation value between any two users should be the same in order to deploy balanced detection.

2.4.1 Optical Orthogonal Codes (OOC)

In fibre-optic CDMA each information bit from the m-th user is encoded into a signal $u_m(t)$ that corresponds to a code sequence of N chips representing the address of that user. The receiver of the CDMA system must be able to correctly distinguish each of the possible addresses based on the conditions shown in [8] that:

1. The peak of the autocorrelation function of u(t) should be maximized as shown below:

$$r_u(\tau) = \int_{-\infty}^{\infty} u(t)u(t-\tau)\,dt \tag{2.2}$$

2. The side lobes of the autocorrelation function $r_u(\tau)$, of u(t) should be minimized.

3. The cross-correlation function of any two signals u_α(t) and u_β (t) in the system should be minimized as shown below:

$$r_{u_\alpha u_\beta}(\tau) = \int_{-\infty}^{\infty} u_\alpha(t)u_\beta(t-\tau)\,dt \tag{2.3}$$

The conditions above are translated as follow for a discrete system

i) Let the sequence of the m-th user be given by$c_m = \{c_m(i)\}_{i=0}^{N}$, then the number of ones, K, for the zero-shift, s = 0, in the corresponding discrete autocorrelation function shown below should be minimized

$$A_{c_m}(s) = \sum_{i=0}^{N} c_m(i)\, c_m(i-s) \quad -N+1 \le s \le N-1 \tag{2.4}$$

ii) The number of coincidences in the discrete autocorrelation functions of the sequence C, for every shift, s (except the zero-shift), s, should be minimized

iii) the number of coincidences for every shift, s, in the cross-correlation function of two sequences C_α and C_β should be minimized

$$A_{c_\alpha, c_\beta}(s) = \sum_{i=0}^{N} c_\alpha(i)\, c_\beta(i-s) \quad -N+1 \le s \le N-1 \tag{2.5}$$

where an event which occurs when two ones from two shifted sequences occupy the same chip is called coincidence.

An optical orthogonal code C is a family of (0, 1) sequences characterized by a quadruple (n, w, λa, λc), where n is the sequence length, w its weight, λa and λc is the maximum value of the out-of-phase auto-correlation and maximum value of the cross-correlation, respectively [10, 11]. The (0, 1) sequences of an optical orthogonal code are called its codewords. A low correlation is an important property of the codewords in order to reduce crosstalk between users. A low autocorrelation indicates that each sequence in the code can easily be distinguished from a shifted version of itself. When the cross correlation is low, codeword can easily be distinguished from any combination of shifted versions of other sequences in C. C_m is the code sequence for the m-th user.

The OOC should satisfy the two properties [11]:

1. Auto-correlation property:

$$\sum_{i=0}^{N} c_m(i)\, c_m(i-s) \le \lambda_a \tag{2.6}$$

Where C_m is the code sequence for the m-the user.

2. Cross-Correlation Property:

$$\sum_{i=0}^{N} c_{\alpha}(i)\, c_{\beta}(i-s) \leq \lambda_c \tag{2.7}$$

The value of the cross-correlation function should be minimized all the time.

2.5 SAC-OCDMA System

OCDMA inherent capability to support dynamic bandwidth assignment, asynchronous networks and multimedia services makes it suitable for deployment of local area networks and access networks [12]. However, OCDMA suffers from different noises such as shot noise, thermal noise, a dark current, multiple access interference arising from other users that can access the network that OCDMA [13]. The MAI is considered a dominating source and it requires a reasonable design of the code sequence that can limit the contribution of the MAI to the power received [1]. SAC-OCDMA has been seen to offer good solution that can reduce the effect of MAI arising from other users [14-16] by using codes with fixed in-phase cross-correlation [17]. Several codes have been suggested for SAC-OCDMA networks which includes the following: OOC code [2], QC codes [7], random diagonal (RD) code [18], MQC code [9], modified double weight code (MDW) [19], multi-diagonal code (MD) [20]. Key properties of the SAC-OCDMA codes is the length of the codes, and construction of the code which is limited by code parameter. Also the ability of the code to support large number of users and or high data rates plays a major role. The cross-correlation is also seen to increase with increase in weight numbers example is the prime and RD codes. In Table 2.1, we compare the different properties of codes using the code length, weight, and cross-correlation values required for each code type when there are 30 active users in the system.

Table 2.1: Comparison of different properties of SAC_OCDMA codes

Serial No.	Codes	Number of users K	Weight	Code length (T/Tc)	Cross-correlation
1	OOC	30	4	364	1
2	MQC	30	8	56	1
3	MDW	30	4	90	1
4	EDW	30	3	60	1
5	MD	30	2	60	1
6	RD	30	4	35	Variable in code segment

From the codes, MQC and RD codes show shorter code lengths. However, as shown in [20], the transmission performance of the MD code is significantly better than that of the MQC and RD codes. This shows that achieving a shorter code length does not necessary guaranty higher performance.

2.6 Fiber Bragg Gratings

Fiber Bragg gratings have been used to implement encoder-decoder for optical CDMA systems [9] [16, 21-23] . Fiber Bragg Gratings are made by laterally exposing the core of a single-mode fiber to a periodic pattern of intense ultraviolet light. The exposure produces a permanent increase in the refractive index of the fiber's core, creating a fixed index modulation according to the exposure pattern. This fixed index modulation is called a grating. The block diagram of FBGs transmitter and receiver system is shown Figure 2.2. The description of FBGs in optical encoder and decoder system is given in Figure 2.2 to illustrate the application when using MQC code.

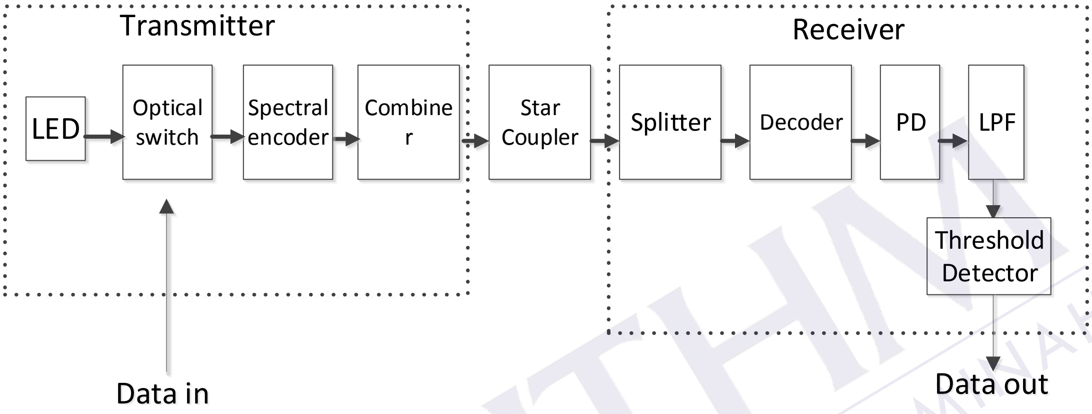

Figure 2.2: Block diagram of the SAC _OCDMA system [14].

Form the block diagram show in Figure 2.3, first a unipolar code is generated and for each bit of data one broad-band optical pulse from the LED is encoded. A pulse is sent with spectral distribution $A(v)$ when the data bit is one “1” and a pulse with complementary spectral distribution $\bar{A}(v)$ when the data bit is zero “0” by the transmitter. The shape of the spectral pulses is arranged according to MQC code. The pulses from all the user in the system are mixed up at the star coupler forming a superimposed signal. In the receiver the received optical signals is split and decoded by two complimentary decoders. A balanced detection is performed and with the help of the low-pass filter (LPF), and threshold decision, the original data is recovered. A more detailed description is shown in Figure 2.3.

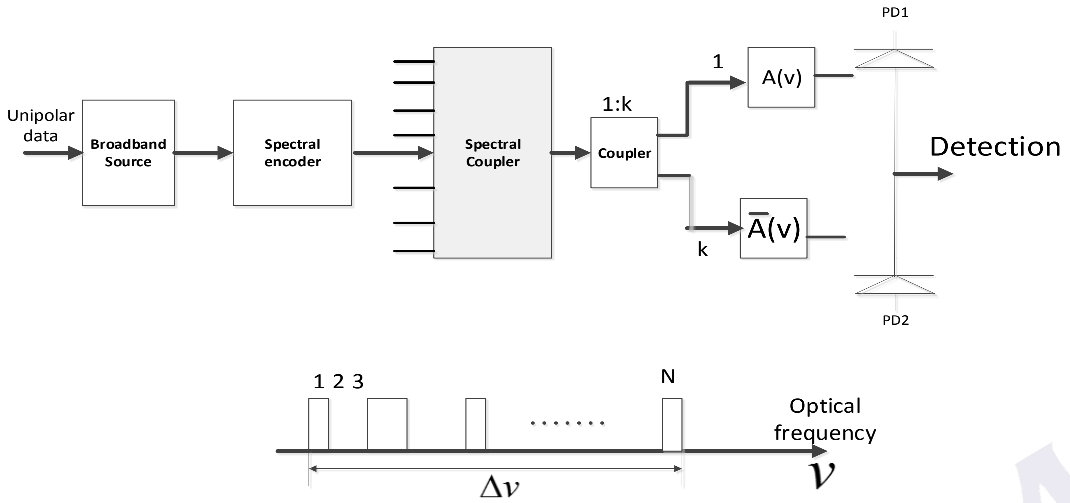

Figure 2.3: Block diagram of SAC OCDMA system using MQC code [14].

AT the receiver side, a 1: k splitter is used to divide the received signal into two parts which goes into two decoders with complementary decoding functions. When (N, w, λ) code is used, the MUI coming from $(k-1)$ undesired users at the first photo detector (PD1) is equal to $(k-1)\lambda$ and that at PD2 is equal to $\alpha(\mathrm{w}-\lambda)(\mathrm{k}-1)$. When $\alpha = \lambda / (w-\lambda)$, the two MUI components are equal which cancels out after balanced photo detection [24].

2.6.1 The Transmitter based on FBG

The description of the transmitter and receiver based FBG is given in [9, 21]. The structure of the transmitter is shown in Figure 2.4. When a broad-band pulse is input into a group of FBGs, the spectral components corresponding to will be reflected back, and the output at the other end of the grating group will contain all the complementary components corresponding to $A(v)$, as shown in figure 2.5.

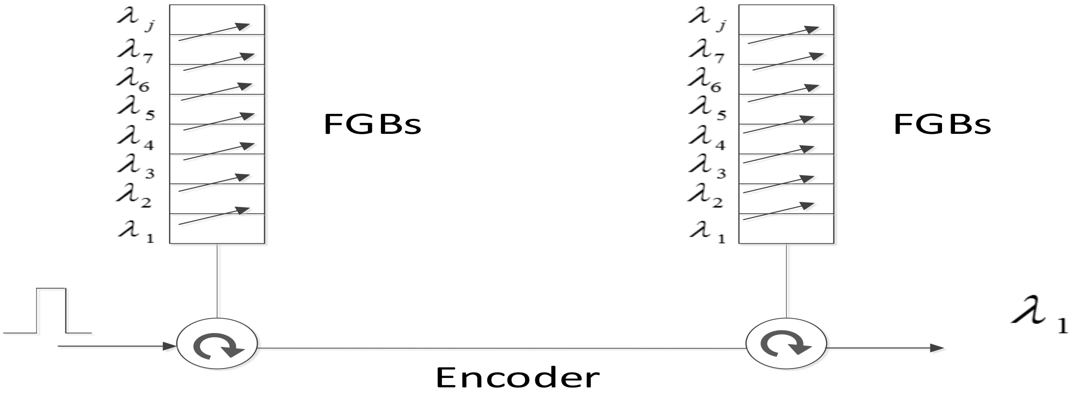

Figure 2.4: Structure of the transmitter [14].

Figure 2.5: Representation of the FBG's Function [14].

2.6.2 The Receiver based on FBG

In the receiver shown in Figure 2.6, the output from the top of the first FBG group is used directly as the decoded output, where is the received signal and is the complement of the receiver address sequence. When bit "1" is sent, an optical pulse from a broad-band thermal source (BTS) launches into the encoder, whereas no optical pulse is sent if the data bit is "0." The optical pulse passes through the first fiber-grating groups and correspondent spectral components are reflected. For the reconfiguration of the destined address code, the gratings in the encoder are all tunable, which means the central wavelength of the reflected spectral component of each grating can be changed. The second group of FBGs in the transmitter is used to compensate the round-trip delay of different spectral components so that all the reflected components have the same time delay and can be incorporated into a pulse again. At the receiver, each grating is fixed according to the receiver's address. MUI can be cancelled by balanced detection because the in-phase cross correlation between any two code-sequences is always equal to 1.

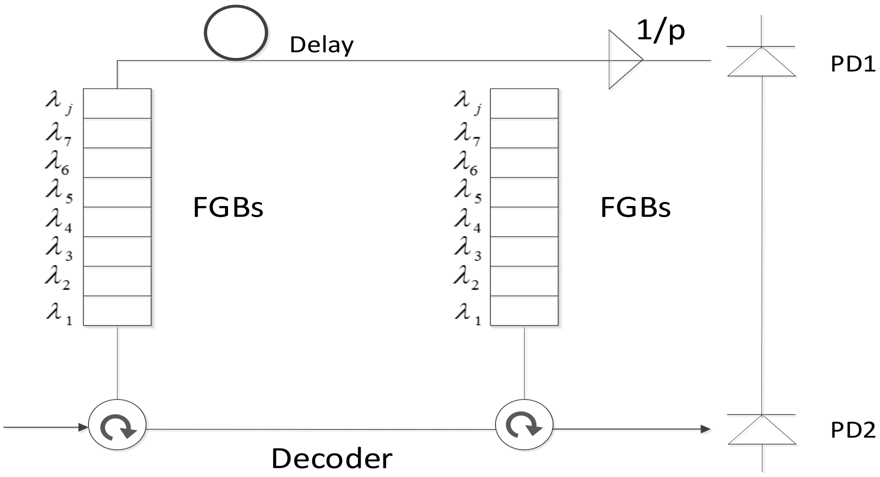

Figure 2.6: Structure of the receiver [14].

2.7 Encoding Technique

Each of the transmitters is made up of encoders. The structure of a basic encoder is shown in Figure 2.7 where data to be transmitted is generated from a known source. The sequence generator generates the set of codes based on any selected coding scheme as shown in Table 2.1 Section 2.5. The generated codes are modulated with data for transmission using a modulator. For example, a user sends a data sequence ‘10’ and the assigned CDMA code is ‘10100’. The modulated signal of the user is ‘10100 00000’. In this case the length of the code is 5, the data rate becomes 5 times lower than the chip rate. The modulate signal is the multiplication of the data signal with the OCDMA code. The coded signals then modulate a laser source which generates the optical DS-CDMA waveform.

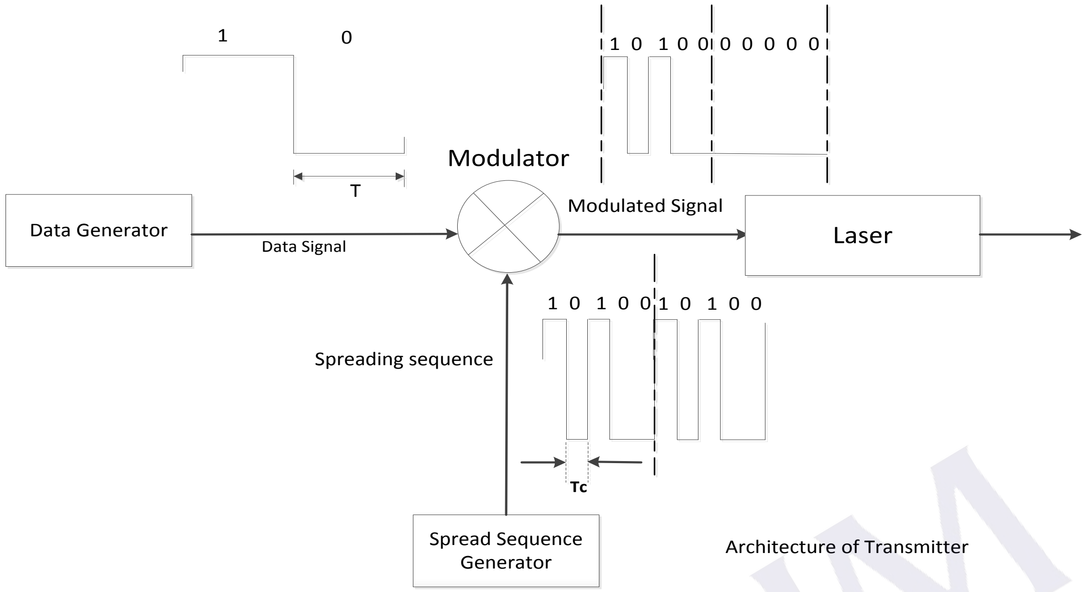

Figure 2.7: Basic structure of encoder [18].

2.8 Detection Technique

The detection techniques can be classified into two, which are: direct detection and balanced detection. A simple detection scheme is the direct detection (also called peak detection). In most optical CDMA systems, detection is performed in the optical domain by using an optical correlator and a threshold detector such as in [3] and [6]. The balanced detection consist of two photodiodes connected electrically in opposition. The output signal is proportional to the power difference between the two optical inputs. The balanced detection technique enhances system performance compared to direct detection technique but with increased receiver complexity.

a) Modified-AND subtraction detection technique:-

In the SAC-OCDMA, appropriate detection technique is required to reduce the MAI. The most common technique used to extract user signals in the presence of other interferes are AND subtraction detection [25] and complementary subtraction detection technique [26]. Another detection technique is the modified-AND detection technique proposed in [27]. The SAC-OCDMA receiver structure of the modified-AND subtraction detection technique is shown in Figure 2.8.

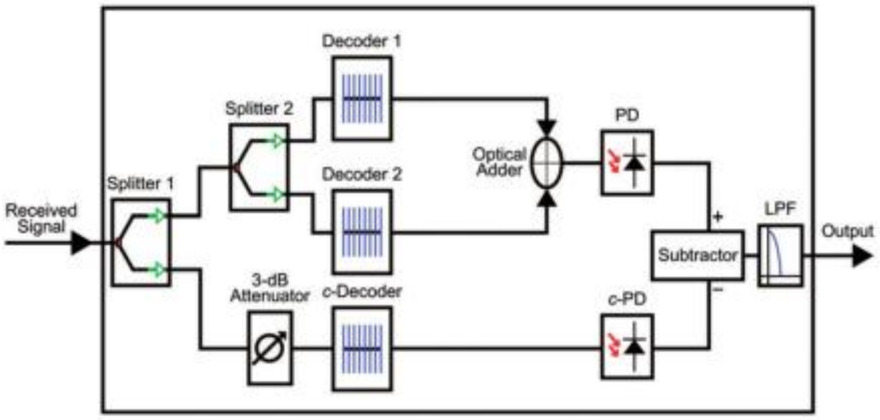

Figure 2.8: SAC-OCDMA receiver based on modified-AND subtraction detection technique [27]

The AND and modified-AND utilise the balanced detection technique which requires two photodiodes. In recent work, single photodiode detection (SPD) technique has been proposed in [16].

b) SPD detection technique

The technique utilises single photodiode and has the potential to reduce the cost of receiver and shot noise. The block diagram of the SPD SAC-OCDMA technique is show in Figure 2.9.

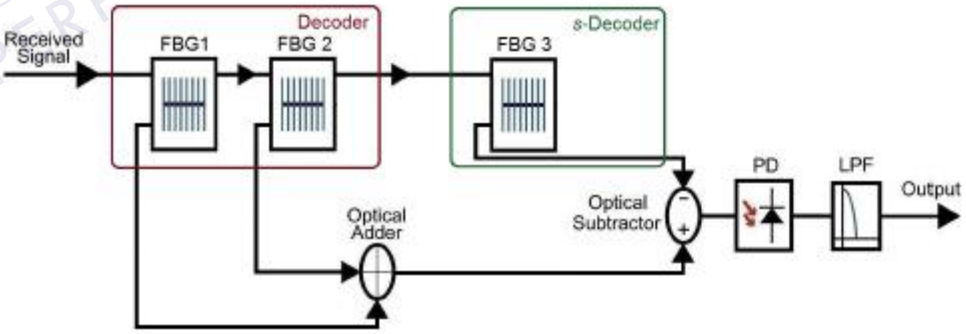

Figure 2.9: SAC-OCDMA receiver based on SPD technique [16].

From the block diagram, the incoming received optical signal is decoded by decoder implemented using low complexity FBGs. The SPD detection technique can be used to implement any fixed in-phase cross-correlation code with simple modification in the spectral distribution of the s-decoder. The summary of SPD block diagram is described here and full details can be found in [16]. The decoder has an identical response to the intended encoder for the data received. The detected output from the decoder is either w power units (P.U.) for active user or λ_c P.U. for interferers. The weight w represents the number of occupied frequency bins in the user's encoder, and the in-phase cross-correlation λ_c, which is the maximum number of common frequency bins occupied by any two codes of the family. The remainder of the signal from the decoder is then transmitted to the subtractive decoder (s-Decoder) to cancel out signals with mismatched signatures, i.e., interferers [16]. The s-Decoder contains only frequency bins from different interferers. The output from the s-decoder is either zero P.U for active user or λ_c P.U for interferers. After optical subtraction, the output is either w P.U. for active user or zero P.U. for interferers which implies that the interference signals are cancelled in the optical domain. After the desired signal is detected by a photodiode, the data-carrying electrical signal is low pass-filtered by a Bessel-Thompson filter of order four to reject the out-of-band high-frequency noise. The three detection technique will be used in this project for performance analysis and modified MQC code.

2.9 Summary of previous work

The summary for the previous work cited in this chapter is provided in the Table 2.2.

Table 2.2: Summary of previous work

Year	Author	Technique	Advantages/Disadvantages
2013	Al-Khafaji, H.M., et al.	SPD detection technique for Spectral Amplitude Coding-OCDMA system for reducing BER	The advantages are reduction in complexity and cost compared to AND and modified-AND detection technique. Also minimize PIIN and MAI in coherent SAC-OCDMA. The limitation to this technique is that it is assumed that the interference signals

			at the optical subtractor of the SPD are assumed to be equal and cancel each other. In practice the interference signal differs slightly.
2012	Abd, T.H., et al	Use of multi-diagonal (MD) codes for SAC-OCDMA	Advantages are simplicity of design, support for large number of users with high data rates and zero cross-correlation that cancels MAI. The limitation are MQC and RD codes offer shorter code length compared to MD codes
2012	Al-Khafaji, et al	Use of modified-AND subtraction detection technique for incoherent SAC-OCDMA using MQC code	Advantages are the modified-AND detection technique offers better BER performance compared to AND detection and higher data rate using MQC code. Limitation is higher complexity and cost compared to the AND detection technique
2009	Fadhil, H.A	Use of Random diagonal (RD) code	The advantages are better performance compared to systems encoded with Hadamard, MQC and MFH codes. Simple encoder/decoder design.
2001	Wei, Z., H. Ghafouri-Shiraz, and H. Shalaby	Modified Quadratic congruence (MQC) for fiber Bragg-grating based SAC-OCDMA	The advantage includes reduction of PIIN noise which lead to higher SNR. Compared to the hadamard code, the MWC offers lower in=phase cross correlation which makes it effective in reducing PIIN noise. The limitation is the detection technique is complex compared to QC and EQC code because it uses balanced detection.

1993	Marić, S	Quadratic Congruence (QC) codes for use in spread-spectrum fiber-optic LAN	The advantages is the QC code offers auto-correlation and cross-correlation compared to the prime codes developed earlier with reduced complexity. The limitation is the length of code sequence is high which reduces the data rate for number of users
1983	Shaar, A. and P. Davies	Prime Sequence (PS) for channel code division multiplexing	The advantages of the PS is multiplexing sequence with peak value of periodic cross correlation function. The limitation is longer length of code sequence which reduce data rate of users.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the steps taken to carry out this research is discussed. The operational framework for the research is explained in Figure 3.1. The implementation of the different coding scheme will be explained in section 3.3. The FBG system for the transmitter and receiver is described and the encoder and decoder are explained.

3.2 System operational framework

The operational framework for this research is shown in Figure 3.1. The literature review stage is discussed in Chapter 2. The basic theory of the OOC codes for CDMA was discussed. The understanding from the basic theory is used to develop Matlab codes used for simulation purpose.

In the system design, the number of users, type of encoding and decoding scheme was considered. The simplicity use of simulator and ability to visualise the effect of choosing different parameters were also considered. The layout of the interface was done first using the GUIDE tool box in Matlab. The matlab tool was chosen because it offers already built library that allows for easy implementation of the graphical user interface design compared to other high level languages such as Java, C or C++.

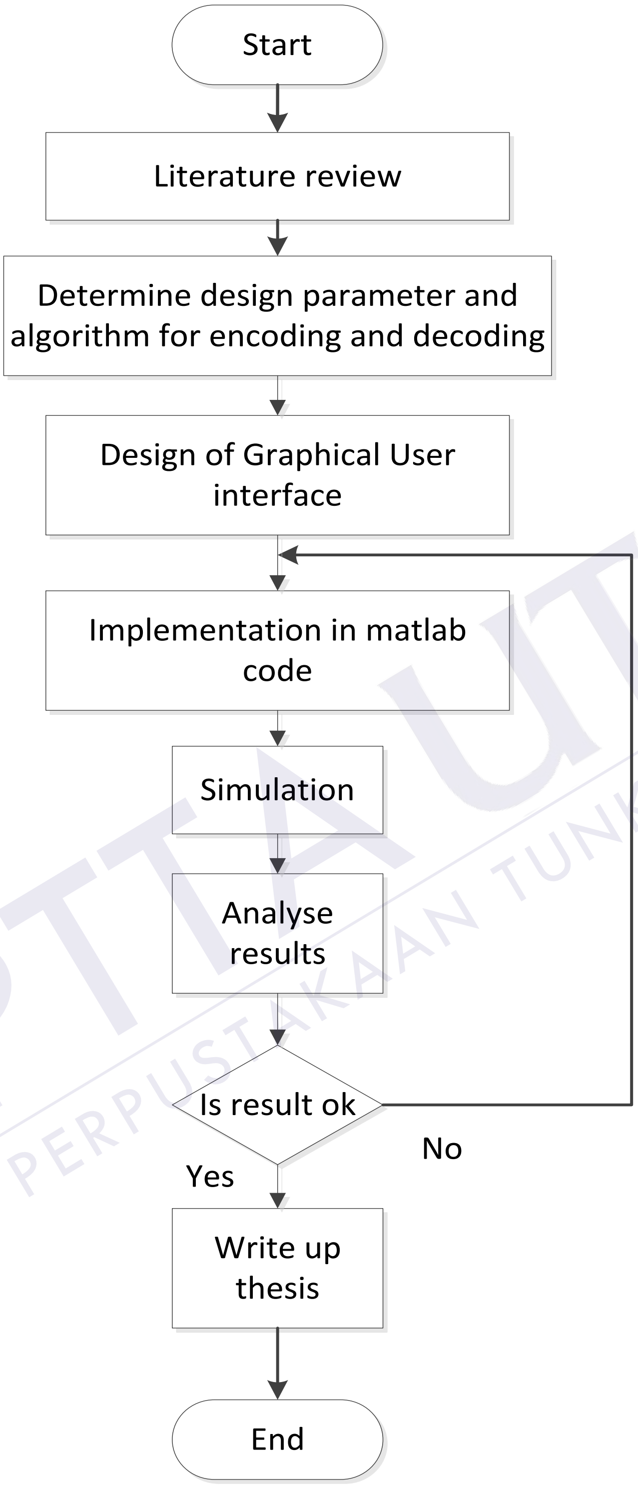

Figure 3.1: Design SAC-OCDMA Operational frame work.

Implementation of the codes in Matlab requires a good skill in programming. The coding algorithm were translated into Matlab codes for simulation. A top down approach was used to design the Matlab codes as shown in the follow in section 3.3. The simulation of codes where done using Matlab compiler, Errors were debugged using the Matlab editor and the results were displayed using the figure tool in Matlab. The simulated results are presented in Chapter 4.

3.3 Proposed System Design

The block diagram from the transmitter to the receiver using encoder and decoder is shown as follows:

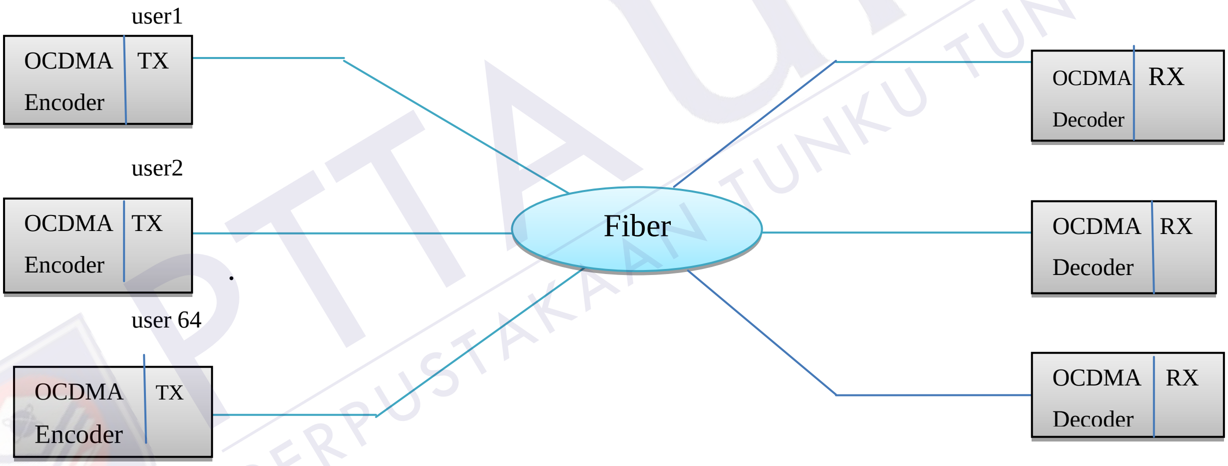

Figure 3.2: Proposed block diagram of Tx/Rx OCDMA Communication using 64 users.

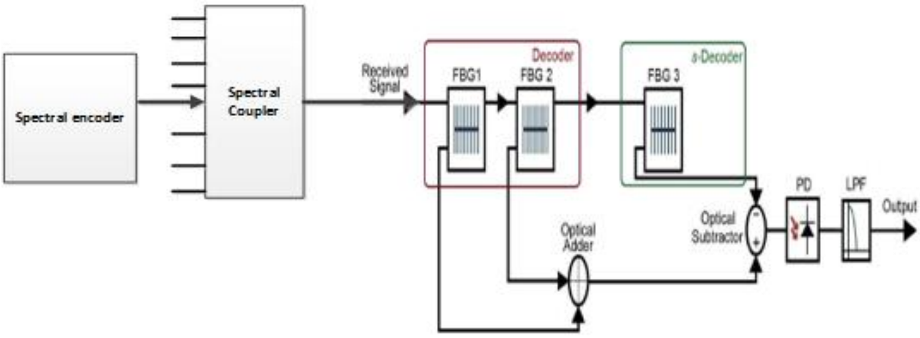

Figure 3.3: Block diagram of Encoder and Decoding scheme.

All data generated by each user is encoded and sent to the spectral coupler. The pulses from all users are mixed up at the star coupler, and then this superimposed signal is sent to the receiver. At the receiver, the received optical signal is split and decoded using the selected detection scheme, in this case the SPD detection scheme is used. Then, after balanced detection, low-pass filter (LPF), and threshold decision, the original data can be recovered. The details of the implementation of the encoder is described in sub-section 3.4.

3.4 Implementation of the Encoder using QC, EQC and MQC codes

The description of the system implementation using Matlab codes is presented in this section.

The block diagram for the encoder is shown as follows :

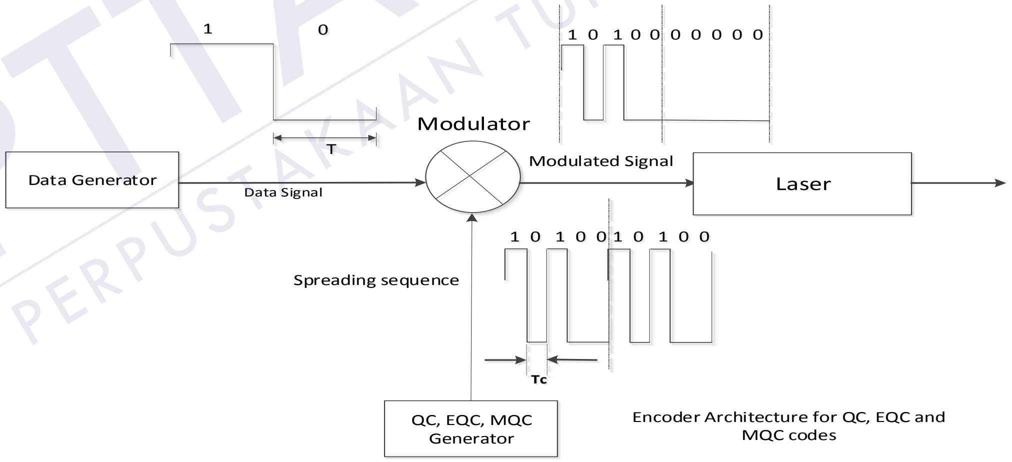

Figure 3.4: Block diagram of the encoder

The simulation of the encoder can be divided into the following four parts:

Step 1. Generation of CDMA codes for each user

Step 2. Generation of binary data for each user

Step 3. Generation of modulated signals for each user by combining (step 1 and 2)

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