
# SUPPRESSING MULTIPLE USER INTERFERENCE (MUI) UZING ZERO CROSS-CORRELATION IN OCDMA

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# SUPPRESSING MULTIPLE USER INTERFERENCE (MUI) USING ZERO CROSS-CORRELATION IN OCDMA

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A final year project report submitted in partial fulfilment of
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# ABSTRACT

Optical Code Division Multiple Access OCDMA is being utilized for it huge data transfer capacity and low attenuation which allow superb video transmission in LAN. OCDMA made a great deal of consideration due it propelled type of multiplexing innovation for the most recent optical systems. OCDMA let multiple users to transmit at a solitary frequency however, when the quantity of users rises, the burst traffic entry approach pattern initiates high Multiple User Interference MUI among users, along these lines corrupting system execution. To fix this issue, Zero Cross-Correlation (ZCC) was introduced where it is a technique with a simple code assembly that accommodates high cardinality. The paper will focus on this code where it provide solution to the issues in OCDMA. The related variable were estimated and the simulation results were being assessed and analysed correspondingly as a designated conclusion to the project. The proposed code reveals properties of zero cross-correlation and supports a large number of users. Simulation results reveal that the OCDMA system based on the proposed ZCC code accommodates maximum number of simultaneous users with good data rate transmission, low Bit Error Rate (BER) and good travel distance with very minimal to none signal quality degradation. The code perform very good at BER $10^{-9}$ in terms of number of simultaneous users.

# ABSTRAK

*Optical Code Division Multiple Access (OCDMA)* digunakan kerana kapasiti penghantaran data yang besar dan gangguan rendah yang membolehkan penghantaran video berkualiti dalam LAN. *OCDMA* menjadi buah mulut kerana ia menggalakkan pelbagai jenis inovasi multiplexing untuk sistem optik terkini. *OCDMA* membiarkan pelbagai pengguna untuk menghantar pada frekuensi masing-masing. Walau bagaimanapun, apabila jumlah pengguna meningkat, kesesakan lalu lintas dalam talian menyebabkan kemunculan *Multiple User Interference (MUI)* yang tinggi di kalangan pengguna, di mana ini akan merosakkan prestasi sistem. Untuk menyelesaikan masalah ini, *Zero Cross-Correlation (ZCC)* diperkenalkan di mana ia adalah teknik dengan pemasangan kod mudah yang mampu menampung jumlah pengguna yang tinggi. Kertas ini akan memberi tumpuan kepada kod ini di mana ia memberi penyelesaian kepada isu-isu dalam OCDMA. Pemboleh ubah berkaitan dianggarkan dan hasil simulasi akan dinilai dan dianalisis dengan sepadan sebagai kesimpulan yang ditetapkan untuk projek tersebut. Kod yang dicadang menunjukkan ianya mempunyai sifar tindihan dan menyokong banyak pengguna. Hasil simulasi menunjukkan system OCDMA berdasarkan kod ZCC mampu menyokong pengguna yang banyak dalam masa serentak dengan tranmisi yang baik, *Bit Error Rate* (BER) yang rendah dan jarak yang bagus dengan pengurangan kualiti signal yang rendah. Kod beraksi sangat bagus dimana menunjukkan BER $10^{-9}$ dengan banyak pengguna yang serentak.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATION

| | | |
|---|---|---|
| OCDMA | - | Optical Code Division Multiple Access |
| MUI | - | Multiple User Interference |
| PIIN | - | Phase Induced Intensity Noise |
| ZCC | - | Zero Cross-Correlation |
| MAN | - | Metropolitan Area Network |
| LAN | - | Local Area Network |
| FTTH | - | Fiber To The Home |
| WDMA | - | Wavelength Division Multiple Access |
| TDMA | - | Time Division Multiple Access |
| CDMA | - | Code Division Multiple Access |
| DWDMA | - | Dense Wavelength Division Multiple Access |
| FDMA | - | Frequency Division Multiple Access |
| PLC | - | Planar Lightwave Circuit |
| PON | - | Passive Optical Network |
| EPON | - | Ethernet Passive Network |
| CATV | - | Community Access Television |
| SDH | - | Synchronous Digital Hierarchy |
| SONET | - | Synchronous Optical Network |
| FDL | - | Fiber Delay Line |
| BER | - | Bit Error Rate |
| SNR | - | Signal to Noise Ratio |

# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

Telecommunication systems and network are expected to provide a variety of integrated broadband services to customers. To satisfy this need, a substantial increase in throughput as well as range of bandwidth supported are required in these integrated network. The advanced developments in fiber for the past 20 years have made possible the use of optical fiber as transmission media in modern communication system. Currently media like the twisted pair cable and coaxial cable is still not capable to dethrone the numbers of advantage provided by optical fibers. Over a long distance, due to the virtually no capping of bandwidth and is proposed as the best solution for broadband access and also little to no attenuation factor, optical fiber present the ability to transmit without signal regeneration or amplification. Besides, number of links required can be reduced thus leads to cost reduction for the end user as multiple channel can be multiplexed to share the same optical fiber medium.

A multiple access technique are communication system where when it wants to send the message or data to different destinations users shares the same transmission medium. Known as one of the greatest significant to support high cardinality in shared media, Optical Code Division Multiple Access (OCDMA) also in some scenario can enhance the transmission bandwidth with an enormous capacity. It also able to utilize the frequency at the same time with no jitter to multiple number users cause the vast amount of attention to OCDMA system.

## 1.2 Background of Studies

The main feature of OCDMA is the orthogonal codes features which enable same overlapping spectral range without causing noises among multiple users. Despite the use of orthogonal codes, multiple user interference (MUI) still cannot be avoided where it the pivotal issue that limits the potent signal to noise ratio (SNR) since it shares the same transmission at the same time [1]. The phase-induced intensity noise (PIIN) in the OCDMA system is strongly linked to MUI due to the overlap of spectra from different users.

The key to a fruitful OCDMA system is the selection of coherent address codes with amazing or nearly zero correlation features for source encryptions. This feature makes it easy to distinguish each codeword from any other address sequence. In facts, this research are trying to make the MUI insignificant in comparison with the received information bit energy. Codes that fulfill this attribute will let the system to operate asynchronously thus reduces the Bit Error Rate (BER) by handling the term of noise of MUI [1].

## 1.3 Problem Statement and Motivation toward studies.

OCDMA created a lot of attention due it advanced form of multiplexing technology for the latest optical networks. Despite being the latest advanced form of technology, it cannot run away from limitations. The pivotal issue in OCDMA system is finding a coding system that are able to nullify the co-channel interference consequences. Besides, OCDMA also suffers from Phase Induced Intensity Noise (PIIN) [2]. Finding a coding system that are able to nullify the co-channel interference consequences are the main motivation for this thesis.

Multiple User Interference (MUI) is one of the prime cause of execution reduction for high cardinality in any OCDMA system. In OCDMA systems, MUI critically affects the entire system operation due to the in-phase cross correlation $\lambda$ and the inherent phase induced intensity noise (PIIN). MUI noise results from improperly decoded channels that pass through the decoder and occur on the photo detector. This MUI restricts the execution of the system by the quantity of channels [2].

As stated above, Phase Induced Intensity Noise (PIIN) has a strong connection with MUI. It results from the mixture of two uncorrelated light fields with the exact polarization, minimal self-intensity noise, the identical spectral attribute and the equal intensity [2]. The PIIN increases the spectrum over the highest permissible electrical bandwidth, critically affecting the entire system execution.

The research therefore focuses heavily on developing the OCDMA code, which is required to minimize the MUI and PIIN. Although the PIIN from the random emission of the broadband source stays entirely, balance detection allows the MUI to be banished[3]. The construction of codes that have the highest auto-correlation and lowest cross correlation is done to effectively distinguish the wanted signal from noise and interference. For this purpose the researches motivated to create the code word in which the outcome of MUI and PIIN of the overall collected power is minimized. Apart from that, OCDMA is famous for its cellular radio network and optical fiber also plays a major role in digital communication because it can accommodate fast and quick LAN, MAN and FTTH systems. As a result, these motivates researchers where for the implementation of optical communication system, several studies that involves the advantages of CDMA are performed.

## 1.4 Research Objectives

- To study the suppressing of Multiple User Interference (MUI) using Zero Cross-Correlation Code in Optical Code Division Multiple Access OCDMA.
- To design and simulate the optical fiber communication in OCDMA by reducing the MUI and PIIN using Zero Cross-Correlation technique.
- To analyze the performance of the ZCC Code in optical fiber communication OCDMA.

## 1.5 Scope of Research

In the scope of research, it will focus on Zero Cross- Correlation (ZCC) Code where it is a newly developed code structure in OCDMA. The research show that the ZCC Code are able to eliminate the PIIN and significantly improve system performance. There will also be a performance evaluation of the proposed code for optical fiber communication. Besides, the research also determine how this technique will eventually improve the optical fiber communication in OCDMA.

OCDMA have been use in many application such as MAN, LAN and ACCESS. The devices usually use in OCDMA is encoder and decoder where encoder is placed at the transmitter meanwhile decoder is placed at the receiver part.

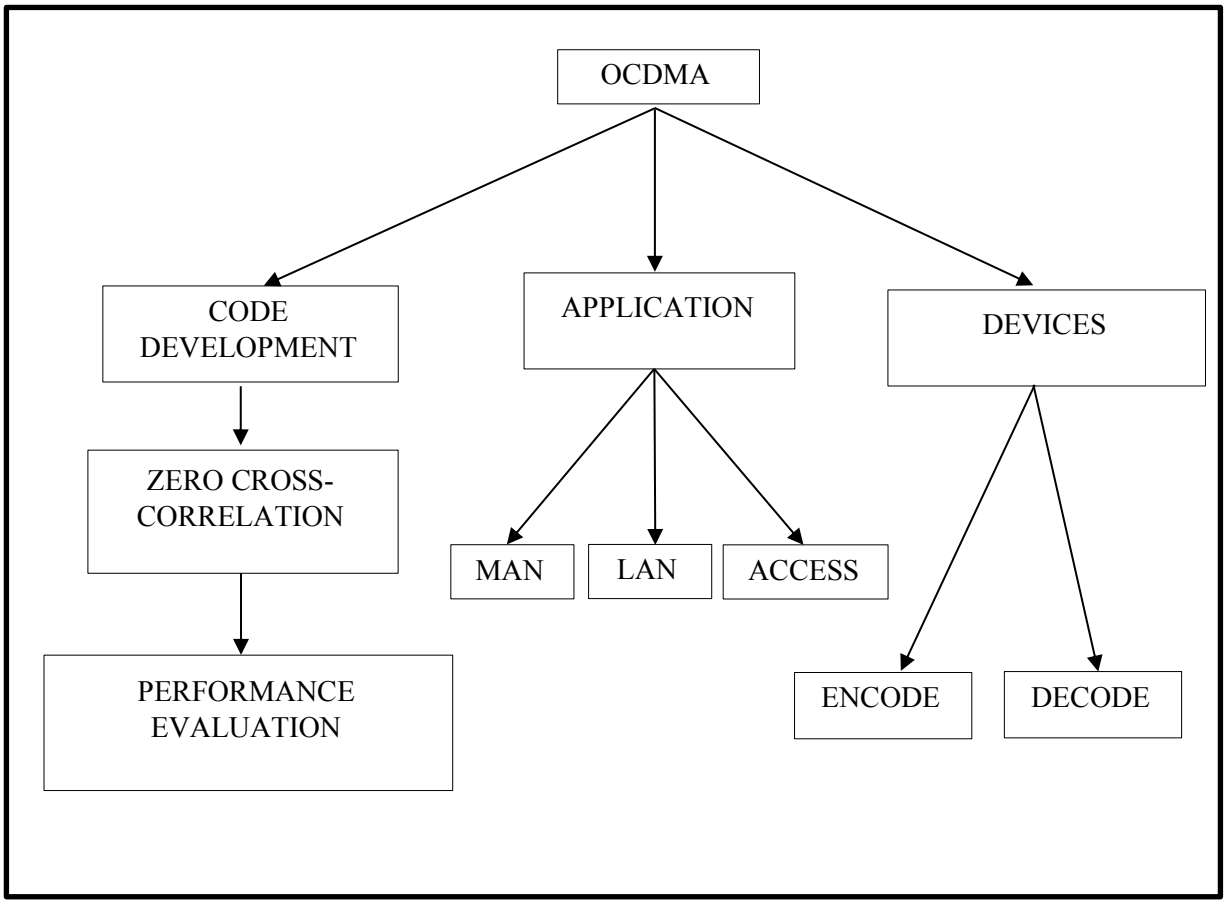


**Figure 1.1:** A general model Scope of Research

In this thesis, Figure 1.1 shows a scope of works general model which is focusing on Zero Cross-Correlation (ZCC) Code development for OCDMA. From the figures, the execution of the Zero Cross-Correlation Code has been simulated and analyzed. Nevertheless, as far the scope of works is concerned, the software simulation is expected to be sufficient to prove the viability of the proposed ZCC Code and their superior performance. In development of a new class of OCDMA codes, more research and study need to be explored and understanding of derivation and calculation of the system most required.

## 1.6 Thesis Outlines

This research consist of five chapters that are introduction, literature review, methodology, result and discussion, conclusion and recommendations.

Chapter 1 describe the overview of the optical code division multiple access OCDMA. This chapter also explain in details the introduction, background of studies, problem encountered, research objectives, scopes of work and the research outline.

Chapter 2 presents the literature review of the research background. The methodology of the concept, theory, and several characteristic of components of hardware that utilized in this venture are talked about in this section. This chapter also discussed the concept of the research that how it is related with the theory, defines the terms that handled in this project. Besides, the challenges, effect and etc. were included in this chapter.

Chapter 3 describes the details of methodology used in this research. The timeline must be completed the research and the detailed reported regarding the studies about the research. This is required in order to get solution and analysis of the research.

Chapter 4 contains the results and discussion. All the simulations must be taken for the part of the result outcomes for discussion. The outcomes will matched with the points outlined in order to satisfy for some conclusion and hypothesis.

In Chapter 5, it discuss about the conclusion and future work that must take on in the future as the seed to plan new extend. Some suggestion and recommendations on how to exceed the performance of the system based on the desired results will be given.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter provides details about the Multiple Access Technologies and the OCDMA system. It starts with a discussion on existing Multiple Access Technique, comparison of multiple access schemes, OCDMA, multiple user interference (MUI) and Zero Cross-Correlation (ZCC) Code technique.

## 2.2 Multiple Access Technique

In communication system, the idea of multiple access not only permit frequency band sharing among different users but also simultaneous information can be transmitted past a single communication channel is granted. Multiple access techniques are used to enable many mobile users to share the allocated spectrum as efficiently as possible. Excess bandwidth provided by optical fibers for multiple access engagements, allowing number of users to interact simultaneously using the identical medium by partitioning and placing the transmitted signal time, bandwidth or some other properties. When using the identical physical medium, it is required for the multiple access to have combined and separated traffic.

A cell system divide any assigned area into cells in which a mobile unit in each cell can communicate with a base station. The key target in the cell system configuration is to offer expanded channel limit. This is to oversee whatever number calls as would be possible in a specific transmission capacity with a satisfactory standard of quality of service. Multiple access technique grant different access to a

channel. A channel speaks to a system resource allocated to a given mobile client that allows the client to set up communication with different clients in the network.

The three main multiple access techniques are Wave Length Division Multiple Access (WDMA), Time Division Multiple Access (TDMA), and Code Division Multiple Access (CDMA) [4]. Fiber optic communications frameworks traditionally use one or the other of TDMA or WDMA systems to designate bandwidth to number of users. TDMA and WDMA are used to divide the bandwidth between multiple users in fiber optic communication [4]. WDMA is an innovation that enables various clients to get to a channel by budgeting wavelength or frequency to every user in each channel [4, 5]. Meanwhile, TDMA is a technology where it let number of users to enter a channel by designating time vacant within each channel to each user [4, 5]. For CDMA, it is an attractive wireless communication technique that offers better performance than other existing multi-access techniques [4]. The advantages and disadvantages of these three techniques are shown in Table 2.1.

WDMA/FDMA was the initial multiple access for cell frameworks. In this technique a client is appointed a couple of frequencies while setting or accepting a call. One frequency is utilized for downlink (base station to mobile) and one sets for uplink (mobile to base). This is called frequency division duplexing. That frequency pair is not utilized in a similar cell or nearby cells amid the call. Despite the fact that the client may not be talking, the range can't be reassigned as long a call is set up. Two second era cell frameworks (IS-54, GSM) use time/frequency multiple access whereby the accessible range is partitioned into recurrence spaces (e.g., 30 kHz bands) yet then every frequency slot is isolated into time slots. Every client is then given a couple of frequencies (uplink and downlink) and a time slot amid a frame. Various clients can utilize a similar frequency in a similar cell aside from that they should transmit at various occasions. This method is additionally being utilized in third generation wireless systems.

Code division multiple access technique enable numerous clients to at the same time get to a given frequency allocation. Client partition at the recipient is conceivable due to every client spreads the balanced waveform over a wide data transmission utilizing special spreading codes. There are two essential sorts of CDMA. Direct-sequencen CDMA (DS-CDMA) spreads the signal directly by duplicating the information waveform with a client that have unique high transfer speed pseudo-noiser

binary sequence. The subsequent signal is then mixed up to a baseband and transmitted. This adequately (expecting flawless synchronization) expels the pseudo-noise signal and what stays (of the ideal signal) is only the transmitted information waveform. After evacuating the pseudo-noise signal, a channel with transfer speed corresponding to the information rate is applied to the signal. Since different clients don't utilize totally symmetrical spreading codes, there is remaining multiple user interference present at the channel yield.

Table 2.1 Advantages and Disadvantages of WDMA, TDMA and CDMA respectively

| Multiple Access Technique | Advantages | Disadvantages |
|---|---|---|
| WDMA | a) Given over their own channel<br>b) User permitted at the same time<br>c) High bandwidth efficiency | a) Channel crosstalk<br>b) Channel idle most of the time<br>c) Non-linear effcet |
| TDMA | a) Given over their own channel<br>b) Great throughput<br>c) Deterministic entry | a) Requires exact synchronization<br>b) Not productive in burst traffic<br>c) Bandwidth disused<br>d) Inefficient use of channel<br>e) High cardinality degrade the performance |
| CDMA | a) User permitted at the same time<br>b) Asynchronous access<br>c) Delay or scheduling not presence<br>d) Great bandwidth productivity<br>e) Productive for burst traffic<br>f) Given their own channel | a) High cardinality degrade the performance. |