DUBLIN CITY UNIVERSITY

ELECTRONIC AND COMPUTER ENGINEERING

EE515 Real-Time DSP: Assignment 1

The role of Digital Signal Processing in Optical Communications Systems

Author

Michael Lenehan michael.lenehan4@mail.dcu.ie

Student Number: 15410402

25/11/2019

Declaration

I declare that this material, which I now submit for assessment, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work. I understand that plagiarism, collusion, and copying are grave and serious offences in the university and accept the penalties that would be imposed should I engage in plagiarism, collusion or copying. I have read and understood the Assignment Regulations set out in the module documentation. I have identified and included the source of all facts, ideas, opinions, and viewpoints of others in the assignment references. Direct quotations from books, journal articles, internet sources, module text, or any other source whatsoever are acknowledged and the source cited are identified in the assignment references. This assignment, or any part of it, has not been previously submitted by me or any other person for assessment on this or any other course of study.

I have read and understood the DCU Academic Integrity and Plagiarism at https://www4.dcu.ie/sites/default/files/policy/1%20-%20integrity_and_plagiarism_ovpaa_v3.pdf and IEEE referencing guidelines found at https://loop.dcu.ie/mod/url/view.php?id=448779.

Signed: ___________________ Date: 08/04/2019

Michael Lenehan

EE-515 Real-Time DSP Assignment 1

The role of Digital Signal Processing in Optical Communications Systems

Michael Lenehan

Abstract

Contents

1 Introduction

Modern optical communications systems have been in use since the 1960's, with the first commercial usage in 1977 in California, where telephone traffic was transmit at a rate of 6Mbps[1]. Since this time, systems have been implemented to transmit data for applications such as telephony, cable television, and internet data.

This literature review will present a history of the usage and implementations of optical communications systems, and an overview of the applications of the technology.

Following this, a review of the current "state of the art" within the field, as it applies to digital signal processing, and the modulation algorithms implemented, will be completed.

2 Background

In order to understand the "state of the art" within the field of optical communications systems with relation to digital signal processing, it is necessary to have a level of understanding of its background. This section will introduce the basic physics concepts, an generalised overview of a typical optical communications system, along with the advantages an optical communication system offers.

2.1 The Physics of Optical Communications

Optical communications systems utilise light, typically provided by laser diodes, or LED's, in order to transmit information along an optical fiber cable. The optics principle of total internal reflection is utilised for the purpose of transmission. When the incident angle of the light in the cable is greater than the critical angle at the "core-to-cladding interface"[1], the light will reflect back into the core. This repeats thoughout the fibers core, passing the light from source to destination.

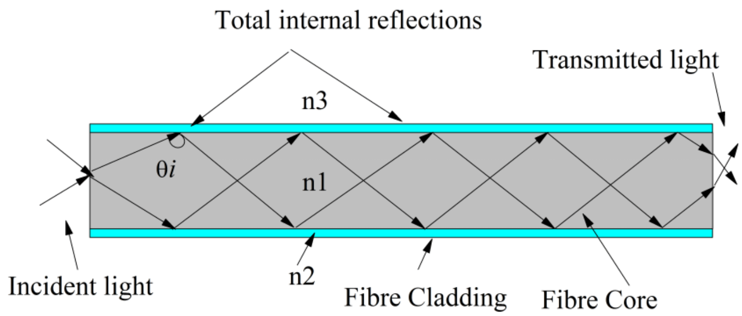

Figure 1: Total Internal Reflection within an Optical Fiber Cable[2]

Optical communications systems utilise light in the infrared spectrum to pass information along a cable. The wavelength of the light in this spectrum is in the order of thousands of micrometers (μm) in length, with frequencies in the order of hundreds of terahertz ($\approx 10^{13} Hz$). These high-frequency, low-wavelength carrier signals result in very high bandwidths, and very high data transfer rates[3].

The directionality of laser light within these systems allows for greater efficiency, as energy is not required for the filtering or correction of divergent beams[3].

2.2 Optical Communications System Overview

Optical communications systems are typically composed of the components listed in figure 2, that is a light source, an information source, an encode and modulator, optics at both the transmitting and receiving side, a transmission medium, a detector, and a receiver.

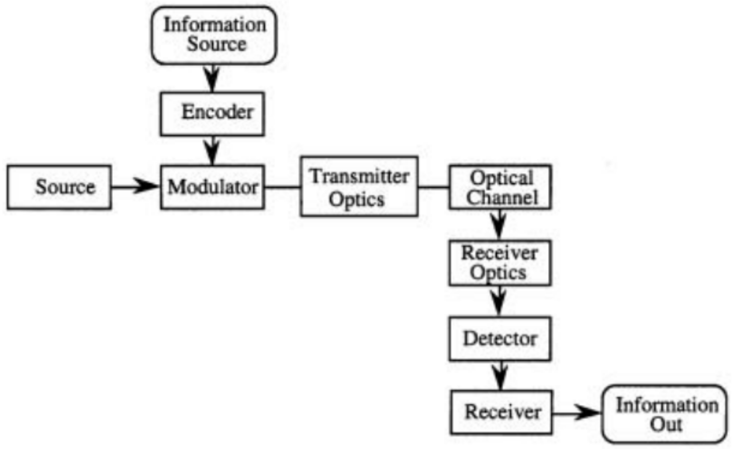

Figure 2: Generalised Block Diagram of an Optical Communications System [3]

As previously discussed, the light source used is typically an LED or a laser diode (LD). Laser diodes offer advantages in modulation speed, power and spatial coherence[1].

At the transmission side, the incoming source must be modulated with the data signal. The modulation techniques used, and the most recent advances in these techniques will be the main focus of this review paper.

At the receiving side, a photodiode converts the incoming light signal to an electrical signal. This is typically followed by multiple amplication stages, and can also include circuitry for decoding the signal, or error detection[1].

2.3 Optical Communications System Advantages

There are many advantages to using optical communications systems over traditional communications systems using, for example, copper wire. Optical communications systems allow for greater resistance to interference and signal attenuation, which can cause problems in traditional systems.

2.3.1 Interference

Interference can be present in traditional data transmissions through a phenomenon known as "Crosstalk" which occurs when signals within different channels of a system have an adverse, interfering effect on one another[4]. While this is an issue within the traditional data communications systems, limiting the amount of lines which can be run in close proximity, it poses no such issues within optical communication systems (provided there is adequate cladding in place[3]).

Optical data transmission is relatively resistant to interference, both in terms of Electromagnetic, and Radio-Frequency interference, thus making them more suitable than metal based, traditional transmission systems in situations where there is high liklihood of these types of interference[1].

2.3.2 Attenuation

Attenuation in optical systems is much less of an issue than in its metal based counterpart. This is due to attenuation being mainly caused by absorption and scattering within the transmission medium[1]. Within glass cable, this attenuation is extremely low, however, with plastic core cable, it can be higher, due to impurities within the material[1].

Attenuation within traditional systems is higher due to the "skin effect" which increases attenuation at higher frequencies[5]. Due to this effect, systems utilising copper wire require repeaters at approximately 2-5km intervals, compared to a distance of approximately 50km in fiber optic cabling[3][6].

3 Current

3.1 Modulation Techniques

4 Conclusions

test test **5367579**

References

[1] V. Alwayn, *Fiber-optic technologies*, Apr. 2004. [Online]. Available: http://www.ciscopress.com/articles/printerfriendly/170740.

[2] S. Memon, M. M. Ali, J. Pembroke, B. Chowdhry and E. Lewis, "Measurement of ultralow level bioethanol concentration for production using evanescent wave based optical fiber sensor", *IEEE Transactions on Instrumentation and Measurement*, vol. 67, pp. 780–788, Apr. 2018. DOI: 10.1109/TIM.2017.2761618.

[3] A. Mickelson, *Theory of optical communication: Chapter 1*, Jan. 2003. [Online]. Available: https://ecee.colorado.edu/~ecen5686/.

[4] *Crosstalk*, Sep. 2019. [Online]. Available: https://en.wikipedia.org/wiki/Crosstalk.

[5] W. H. Hayt and J. A. Buck, *Engineering electromagnetics*. McGraw-Hill Education, 2019.

[6] [Online]. Available: https://www.tutorialspoint.com/Comparison-of-Fiber-Optics-and-Copper-Wire.