OPTICAL SOLITON IN LONG HAUL TELECOMMUNICATIONS WITH FIBER LOSS FACTOR

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Bachelor of Electrical Engineering

July 2012

“ I hereby declare that I have read through this report entitle “Optical Solitons in long haul telecommunications with fiber loss factor” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (power electronic and drive)”

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Date : 28th June 2012

OPTICAL SOLITONS IN LONG HAUL TELECOMMUNICATION WITH FIBER LOSS FACTOR

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A report submitted in partial fulfillment of the requirement for the degree of Power Electronic and Drive

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2012

I declare that this report entitle “Optical Solitons in long haul telecommunications with fiber loss factor” is the result of my own research exceptas cited in the references. The report has not been accepted for any degree and is notconcurrently submitted in candidature of any other degree.

Signature : ....

Name : Abdul Hafiz bin MohdTamezer

Date : 28th June 2012

To my beloved mother and father

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ABSTRACT

Solitons is the term in optics that is refers to any optical field that does not change during propagation because of a delicate balance between nonlinear and dispersion effects in the medium. In this research, the propagation of the signal optic was simulated by using friendly simulation software such as OptiSystem. Optical solitons was simulating based on different of the distance of the optical soliton travels in the optical fiber and it’s demonstrate in the optical spectrum analyser. Due to imperfection of optical fiber, the loss of signal occurs in the optical fiber, the optical simulation shows the reduction of the peak power as the signal reach to receiver. A study of the mathematical modeling of the propagation of optical solitons in optical solitons was studied. By comparing the mathematical model with the simulation results, it gives almost the results of the simulation results.

ABSTRAK

Soliton adalah istilah dalam optik yang merujuk kepada mana-mana bidang optik yang tidak berubah semasa perambatan kerana keseimbangan halus antara kesan tak linear dan penyebaran dalam jangka sederhana. Dalam kajian ini, perambatan isyarat optik adalah simulasi dengan menggunakan perisian simulasi yang mesra pengguna seperti OptiSystem. Soliton optik telah disimulasi berdasarkan perbezaan jarak perjalanan soliton optik gentian optik dan ia ditunjukkan di penganalisis spektrum optik. Disebabkan untuk ketidaksempurnaan serat optik, kehilangan isyarat berlaku dalam gentian optik, simulasi optik menunjukkan pengurangan kuasa puncak sebagai isyarat sampai kepada penerima. Satu kajian pemodelan matematik perambatan soliton optik di soliton optik telah dikaji. Dengan membandingkan model matematik dengan keputusan simulasi, ia memberikan keputusan yang hampir sama dengan hasil dari simulasi yang dijalankan.

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LIST OF SYMBOLS AND ABBREVIATIONS

GVD	Group Velocity Dispersion
SPM	Self-Phase Modulation
FWHM	Full width at half maximum
Km	Kilometers
NLS	Nonlinear Schrödinger equations
fNLS	forced Nonlinear Schrödinger equations

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, internet usage has led to high demand for communication services with unprecedented amounts of information transferred over a part to another a part of the earth. As a result, it will require higher transmission rates- especially with the delivery of audio and video files. For example, in an effort to remain competitive, internet providers always need to increase their bit rate of the amount of data they can send per second. Unfortunately, the old analog devices that carry information along copper cables using the electron is now facing great difficulties in responding to the huge demand for information. This is mainly due to the fact that they are too slow and too noisy compared to the fiber optic system. Indeed, optical digital systems can achieve higher bit rates of electronic devices and they can be cheaper in the near future.

Like any other communication systems, fiber optic system consists of transmitter, receiver and transmission medium is fiber optics here. A fibre usually consists of a central part called the core (whose refractive index isn_1) and a peripheral part known as the cladding (whose index isn_2). This emitter is a laser light pulse is injected into the fiber. If we inject light properly into the fiber, the light can be guided through without having to leave the core. After propagating along the fiber, optic signals into electrical signals from the receiver to recover the initial message.

Due to the principle of total internal reflection, this is commonly described by Descartes's law. In order to be able to trap light in the core, it must have ($n_1 > n_2$): the refractive index of the core is greater than the cladding refractive index; critical angle of incidence does not exist. When light travels from one medium to another, lower refractive index, there is a critical angle of incidence under the really light will reflect back into the first medium to light does not penetrate the interface.

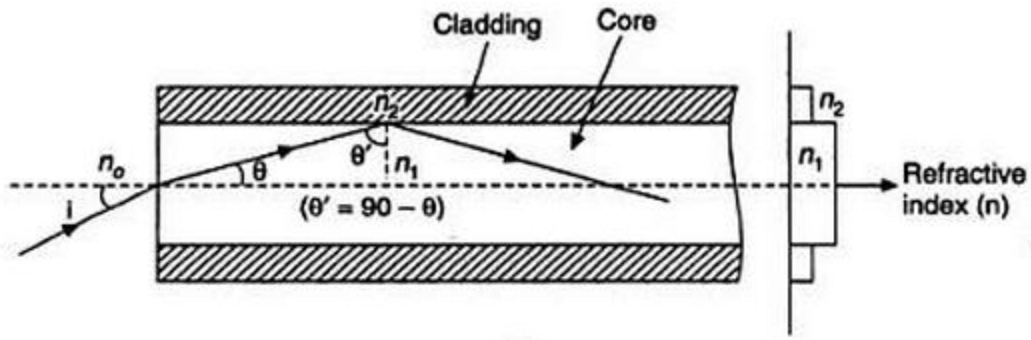

Figure 1.1 Light travels through optical fiber by totally reflecting from opposite wall

Total capacity of fiber that can be delivered is a key factor in determining performance. Due to the encoded data in a series of light pulses, a better delivery rate can be achieved by increasing the number of pulses transmitted in one second. The higher the number of pulses transmitted in one second, better delivery rate. This can be done by reducing the duration of light pulses: a short pulse, the higher the bit rate. For that purpose, some physicists now work on femtosecond laser that can produce ultra-short light pulses. Currently, the shortest laser pulses that we are capable of generating have a time width almost equal to *4 fs* $(4\times10^{-15}\ s)$.

In optics, soliton term used to refer to any optical field does not change during propagation for thin sheet of non-linear and linear effects in the medium term. There are two main types of solitons which is spartial solitons and temporal solitons. Spatial solitons is the nonlinear effect can balance the diffraction. The electromagnetic field can change the refractive index of the medium while propagating, thus creating a structure similar to a graded-index fiber. If the field is also a propagating mode of the guide it has created, then it will remain confined and it will propagate without changing its shape and temporal solitons can be explained if the electromagnetic field is already spatially confined, it is possible to send pulses that will not change their shape because the nonlinear effects will balance the dispersion. Those solitons were discovered first and they are often simply referred as "solitons" in optics.

1.2 Problem Statement

Huge amount of data is transfer though a small, narrow glass cable. The data will convert to the signal before it's transmitting as optical pulses in tiny glass cable-optical fiber. Initially, huge of amount data is transferred through a small, narrow glass cable. The pulse travel in the cable is like waveguide propagation. There have a idea of the optical pulses travel in optical fiber,i.e. normal laser or renovation idea with use of solitons is a very narrow pulse with high peak power. The soliton pulses are in the stable shape and velocity is preserved while travelling along the medium. This means that solitons pulses do not spread in optical fiber after thousands of kilometers. In an optical fiber solitons pulses are generated by counter balancing the effect of the dispersion by the self-phase modulation. It is greatly interest area of new era of commutations in this century. In fact, it is quite impossible to experiment this project into hardware due to high costing and difficult to find the material in this country. However we still can explore the characteristic using OptiSystem that is suitable to find the simulation of the optical soliton.

1.3 Objectives

The project is aimed to meet the following objectives:

1) To simulate the optical solitons propagation with fiber loss in optical solitons problem
2) To investigate the effect of the fiber loss to signal propagation
3) To compare simulated data with mathematical model in optical solitons

1.4 Scopes

In this research, the problem is limited to find the wave propagation using OptiSystem software. The OptiSystem is used to simulate the block diagram of optical solitons and analyze result for long haul telecommunication with fiber loss factor. Due to this project which is used in long haul telecommunication, the single-mode fiber-optic cable will be used because it is provides much better performance with lower attenuation and it is suitable to used in long distance communications.

1.5 Methodology

The studies of the literature review are an important part of starting the research. Therefore, this research is beginning with a review of the literature for optical solitons in long haul communications with fiber loss factor and its application in optical fiber. The collection of information is in hard copy, such as books journals and softcopy like online journal like IEEE in PDF format and also some literature review website. The information was collected through the databases of UTeM library and internet.

The simulation of the optical solitons propagation will be start using OptiSystem software. After the results of the simulations were obtained, the simulation with fiber loss factor will be start using the same software.

After obtaining the results from the simulation, the simulated data from electrical model will be compare with mathematical models which is done by others. The main objective behind this move is to find out whether the obtained result is correct or not. The whole of this project can be summary as in figure 1.2.

1.5.1 Flow Chart of Overall Project

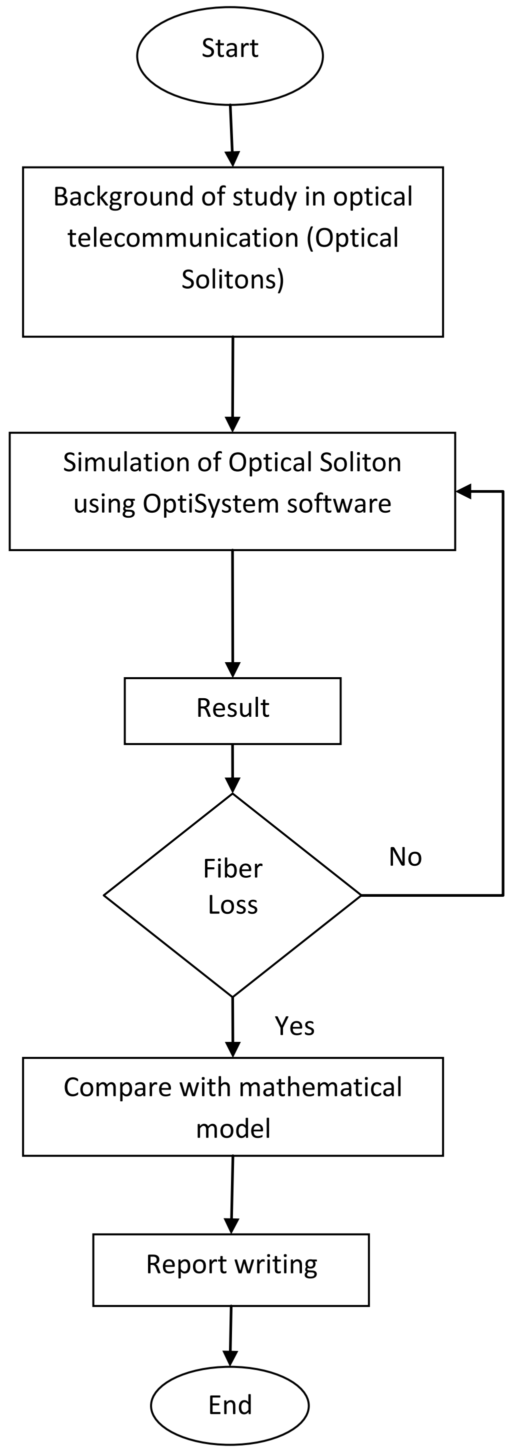

Figure1.2: Flow Chart of Overall Project

1.6 Outline of Thesis

The first chapter is describes the introduction of optical solitons. In second chapter is Literature Review explains about the important things contained in the optical soliton. The third chapter is Optical Solitons Simulation. It is describes about the flow to run the electrical simulation using OptiSystem Software and mathematical simulation using MATLAB software. In the fourth chapter, the results of electrical simulations and mathematical models have been shown and summarized in the fifth chapter of discussion and conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Optical Solitons

A fascinating manifestation of the nonlinear optical fibers occurs through soliton, which is formed as a result of the interaction between dispersion and nonlinear effects. Soliton word that refers to a special type of wave packets can propagate undistorted over long distances. Solitons have been found in many branches of physics. In the context of optical fibers, solitons are not only fundamental interest but they also found practical applications in the field of fiber-optic communication. It describes the nonlinear pulse propagation on dispersive optical fibres such as self-phase modulation (SPM) and group velocity dispersion (GVD).

Optical solitons can be defined as a stable non-linear pulse of light formed in an optical fiber, which has the ability to maintain its shape and width (amplitude) as well as its phase in the presence of dispersion. This attribute is due to an effective cancellation between the dispersion effect and the nonlinear effect.

In the context of nonlinear optics, solitons are classified as being either temporalor spatial, depending on whether the confinement of light occurs in time or space during wave propagation [4]. Temporal solitons represent optical pulses that maintain their shape, whereas spatial solitons represent self-guided beams that remain confined in the transverse directions orthogonal to the direction of propagation.

2.2 Types of Solitons

There are two main kinds of optical solitons.

2.2.1 Spatial Solitons:

The nonlinear effect can balance the diffraction. The electromagnetic field can change the refractive index of the medium while propagating, thus creating a structure similar to a graded index fiber. If the field is also a propagating mode of the guide it has created, then it will remain confined and it will propagate without changing its shape

2.2.2 Temporal Solitons:

For nonlinear optics, there are two main kinds of optical solitons which is temporal solitons and spatial solitons. Soliton wave is realized in many different physical situations, ranging from the mechanical movement of light propagation [5]. In general, they are strong disturbances, which can transmit distortion free for quite a long distance. The strength of optical solitons can be shown in the time domain (temporal solitons), the horizontal space (solitons space), or both (light bullets). Time has been extensively studied Solitons in optical fibers for a great utility in long distance optical communications. They exist as a result of the dissemination of the balance between the competing effects of linear refractive index and nonlinear phase modulation.

2.3 Optical fiber communications

Optical fibers can be used to transmit light and therefore in the distance. Fiber-based system had largely replaced the radio transmitter for optical transmission over long distances [1]. They are widely used for telephony, but also for Internet traffic, long high-speed local area networks (LANs), cable TV, and increasingly also for shorter distances. In most cases, the silica fibers are used, except for short distances, where the plastic optical fiber can be beneficial.

Compared with systems based on electrical cables, fiber-optic communication approach (light wave communication) has the advantages, the most important are:

- The capacity of the fiber for transmission of data: a single silica fiber can carry hundreds of thousands of telephone lines; only use a small part of theoretical capacity. In 30 years, progress in respect of the transmission capacity of fiber links has been significantly faster than for example, advances in computer speed or storage capacity.
- The losses for light propagating in fibers are amazingly small: ≈0.2 dB/km for modern single-mode silica fibers, so that many tens of kilometers can be bridged without amplifying the signals.
- A large number of channels can be reamplified in a single fiber amplifier, if required for very large transmission distances.
- Due to the large transmission rate is achieved; the cost per bit transported may be too low.
- Compared with electrical cables, fiber optic cable is very light, so that the cost of installing fiber optic cables can be much lower.
- Fiber optic cable immune to the problems that arise with electric cables, such as ground loops or electromagnetic interference (EMI).

2.3.1 Classification of Fiber Optic Communications

Single mode and Multimode fibers are the two most common types of fiber. Multimode fiber has light traveling in the core in many rays, called modes. It has a bigger core (almost always 62.5 microns) and is used with LED sources at wavelengths of 850 and 1300 nm for a network of local area network (LAN) and a slower laser at 850 and 1310 nm for networks running on gigabit per second or more. Single mode fiber has a smaller core, only about 9 microns, so that light travels in only one ray. It is used for telephony and community access television (CATV) with a laser source at 1300 and 1550 nm.

The fiber optic communication can be divided into three modes.

2.3.1.1 Multimode Step Index Fiber

Step index multimode was the first fiber design but is too slow for most uses, due to the dispersion caused by the different path lengths of the various modes. Multimode fibres carry many modes of different phase and group velocities. The difference in group velocities of the different modes causes spreading of the temporal envelopes of the individual pulse-excited modes and thus cannot maintain high bit-rate pulse streams(short pulses) over large distances (several kilometers).

Due to its large core, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternate paths cause the different groups of light rays, referred to as modes, to arrive separately at the receiving point.

The pulse, an aggregate of different modes, begins to spread out, losing its well-defined shape. The need to leave spacing between pulses to prevent overlapping limits the amount of information that can be sent. This type of fiber is best suited for transmission over short distances.

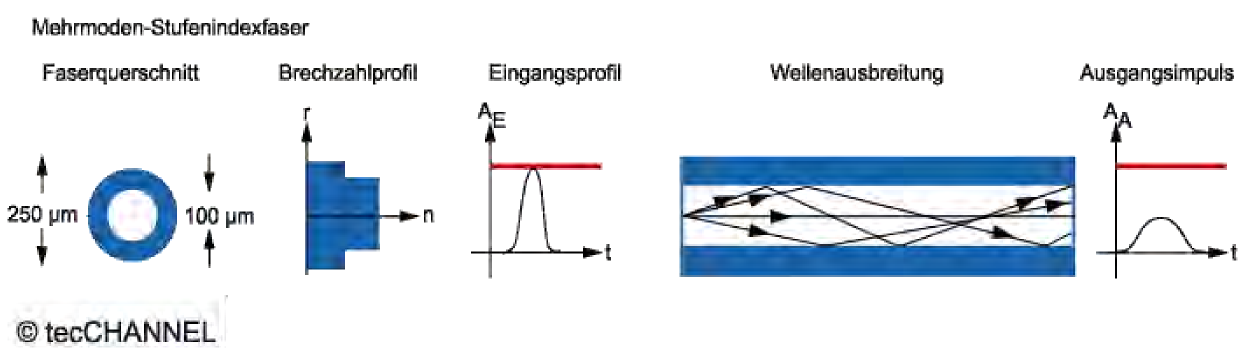

Figure 2.1: Multimode Step Index Fibre