DIGITAL CODING SIMULATION USING MICRO-RING RESONATOR FOR LONG DISTANCE COMMUNICATION

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In the name of ALLAH the Most Beneficial and the most Merciful

Specially dedicated to my beloved Parents and Brothers .

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ABSTRACT

Much interest has recently been expressed in communication through optical fibers, in this project we investigate nonlinear behaviors of light known as bifurcation and chaos within a nonlinear silicon micro-ring resonator (MRR). The research is used to controlling MRR behaviors such as chaos applicable in security signal coding systems. The variable parameters affect the bifurcation to be happened in smaller round-trip among total round trip of 20000 or input power. Therefore, rising of the nonlinear refractive indices, coupling coefficients and radius of the MRR leads to descending in input power and round trips wherein the bifurcation occurs. As result, bifurcation or chaos behaviors are seen at lower input power. In addition, the effect of FSR and FHWM on communication link has been observed. Furthermore, in this work, a performance of nonlinear soliton wave which is generated by Micro ring resonator, in order to be coded and used as a carrier to transmit data over a long distance is investigated ,Controlled chaotic signals from the MRR system are used to generate logic codes of “0” and “1”, which are applicable in wireless network communication.

ABSTRAK

Faedah yang lebih baru-baru ini telah dinyatakan dalam komunikasi melalui gentian optik, dalam projek ini kita menyiasat tingkah laku bukan linear cahaya dikenali sebagai pencabangan dua dan chaos dalam silikon bukan linear mikro cincin resonator (MRR). Penyelidikan ini digunakan untuk mengawal tingkah laku MRR seperti chaos berkenaan dalam keselamatan isyarat sistem pengkodan. Parameter pembolehubah menjejaskan pencabangan dua yang akan berlaku dalam lebih kecil sepanjang perjalanan antara jumlah perjalanan pusingan 20000 atau kuasa input. Oleh itu, kenaikan indeks biasan bukan linear pekali gandingan dan jejari MRR membawa kepada penurunan dalam kuasa input dan perjalanan pusingan di mana pencabangan dua berlaku. Hasilnya, pencabangan dua atau tingkah laku chaos dilihat pada kuasa input yang lebih rendah. Di samping itu, kesan FSR dan FHWM pada pautan komunikasi telah diperhatikan. Tambahan pula, dalam kerja-kerja ini, prestasi gelombang soliton bukan linear yang dihasilkan oleh MRR, untuk dikodkan dan digunakan sebagai pembawa untuk menghantar data melalui jarak yang panjang telah disiasat. Isyarat chaotic terkawal daripada sistem MRR digunakan untuk menjana kod logik "0" dan "1", yang boleh diguna pakai dalam komunikasi rangkaian jarak jauh.

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LIST OF ABBREVIATIONS

LASER	–	Light Amplification by the Stimulated Emission of Radiation
MASER	–	Microwave Amplification by the Stimulated Emission of Radiation
MRR	–	Micro Ring Resonator
FORR	–	Fiber Optical Ring Resonators
CW	–	Continuous Wave
SPM	–	Self-Phase Modulation
OB	–	Optical Bistability
SMRR	–	Single Micro Ring Resonator
TDMA	–	Time Division Multiple Access
EDF	–	Erbium Doped Fiber
PBS	–	Polarizing Beam Splitter
Mux	–	Multiplexer
Rad	–	add/drop filter
E	–	Electric field
Hz	–	Hertz
GHz	–	Gigahertz
BW	–	Bandwidth
L	–	Length
FWHM	–	Full Width at Half Maximum
FSR	–	Free Spectral Range
dB	–	Decibel

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discusses the background of the study including of creation of fiber optic in communication and history of LASER has been investigated. Additionally statement of the problem and the purpose of the study. Along with the objectives of the study, research questions Thesis Organization, and definitions of some terms are also offered.

1.2 Background of Study

The impression of applying fiber to transport an optical communications signal is created by Alexander Graham Bell. Though the idea forced wait about 80 years for well improved glasses with low-cost technology for that to turn out to be suitable in practical circumstances. Progress of fibers and strategies toward optical communications originated in early 1960s and still continues intensely today. An optical fiber is a flexible, transparent fiber made of glass (silica) or plastic, slightly thicker than a human hair. It functions as a waveguide, or "light pipe" [1] to transmit light between the two ends of the fiber [2]. The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. Optical fibers are widely used in fiber-optic communications, which

permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference. Fibers are also used for illumination, and are wrapped in bundles so that they may be used to carry images, thus allowing viewing in confined spaces. Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide. Micro-ring resonator is a type of single-mode fibers which has the input of a LASER beam and generates dark and bright soliton waves which has a nonlinear behavior. In this study we are going to do digital coding simulation using this micro-ring resonator for long distance communication, the functions and procedure of the study will be analyzing in the next chapters.

1.3 A Brief History of Lasers:

Max Plank published work in 1900 that provided the understanding that light is a form of electromagnetic radiation. Without this understanding the laser would not have been invented. The principle of the laser was first known in 1917, when physicist Albert Einstein described the theory of stimulated emission. However, it was not until the late 1940s that engineers began to utilize this principle for practical purposes. At the onset of the 1950's several different engineers were working towards the harnessing of energy using the principal of stimulated emission. At the University of Columbia was Charles Townes, at the University of Maryland was Joseph Weber and at the Lebedev Laboratories in Moscow were Alexander Prokhorov and Nikolai G Basov.

At this stage the engineers were working towards the creation of what was termed a MASER (Microwave Amplification by the Stimulated Emission of Radiation), a device that amplified microwaves as opposed to light and soon found use in microwave communication systems. Townes and the other engineers believed it to be possible to create an optical maser, a device for creating powerful beams of light using higher frequency energy to stimulate what was to become termed the

lasing medium. Despite the pioneering work of Townes and Prokhorov it was left to Theodore Maiman in 1960 to invent the first Laser using a lasing medium of ruby that was stimulated using high energy flashes of intense light. Townes and Prokhorov were later awarded the Nobel Science Prize in 1964 for their endeavors. The Laser was a remarkable technical breakthrough, but in its early years it was something of a technology without a purpose. It was not powerful enough for use in the beam weapons envisioned by the military, and its usefulness for transmitting information through the atmosphere was severely hampered by its inability to penetrate clouds and rain. Almost immediately, though, some began to find uses for it. Maiman and other engineers developed laser weapons sighting systems and powerful lasers for use in surgery and other areas where a moderately powerful, pinpoint source of heat was needed.[3]but in case of optical communication A fiber laser is a laser in which the active gain medium is an optical fiber doped with rare-earth elements such as erbium, ytterbium, neodymium, dysprosium, praseodymium, and thulium. They are related to doped fiber amplifiers, which provide light amplification without lasing. Fiber nonlinearities, such as stimulated Raman scattering or four-wave mixing can also provide gain and thus serve as gain media for a fiber laser.

In the non-mode locking regime, the first soliton fiber laser has been successfully achieved in an all-normal dispersion erbium-doped fiber laser with a polarizer in cavity. Experimentally finding that apart from the bright pulse emission, under appropriate conditions the fiber laser could also emit single or multiple dark pulses. Based on numerical simulations we interpret the dark pulse formation in the laser as a result of soliton shaping.[3]

1.4 Statement of the Problem

Considering the importance of the network communication and data transition, the applications required significantly to have better capacity and higher bitrate which are low in current communication technology, therefore we increase the bitrate by generating highly chaotic signals.

Using micro-ring resonator we can produce both digital and analog waves, by analyzing the analog waves we turn the chaotic noise into logic codes in a digital form, while it has to be coded by applying a coding programming system to provide us a coded soliton which is able to be used as a carrier of signal in optical communication.

We produce analog signals using MATLAB with high capacity and high number of pulses using ring resonator systems.

1.5 Research Questions

In this research there are three basic Questions to be answered:

1. How can we transmit data for long distance communication?
2. How can we use soliton as carrier of digital information?
3. How can we advance transmission of data codes? Perhaps by trying various parameters in micro-ring systems?

1.6 Research objectives

This research aims to achieve the following objectives:

1. To simulate and coding the optical soliton using MRR.
2. Generation of digital signal information codes using MATLAB in MRR system in order to apply in communication technology , whi
ch can be used as carrier of information to transfer it for a long distance communication .
3. Improving the transmission of data codes in order to optimizing the bifurcation and chaotic signals by controlling the power input and other parameters .

1.7 Scope of the study

The scope of this project is first of all design optimized communication system Using nonlinear Micro-ring resonator to provide a Nonlinear condition under the direct impact of nonlinear Kerr effect. After that, simulate the design in terms of performance Parameters Matlab, .Then, optimize the proposed Communication system.

1.8 Thesis Organization

The development of digital communication systems has established new requirements for micro-ring resonator. The motivation for the research in this thesis is to find new approaches for performance improvement of soliton wave to deal with these challenges. After a general overview of basic theories and components of MRR and providing problem statement, objectives, scope of the project in chapter 1, a brief review of micro-ring resonator applications in optical communication systems and a general view of the soliton generation in order to create a communication link, and literature review are presented in chapter2.The project methodology, parameters, simulation tools, the design steps, the software used in the simulation process and the design specifications is discussed in chapter 3. An illustration of simulated results, optimizing the system specification, the advantages of the proposed design, discussions for results including tables and Matlab codes are also provided in chapter 4. Chapter 5 contains the conclusion of the project and the recommended future work.

1.9 Summary

In this chapter, an overview of the optical fiber communication system and LASER is presented. This overview concentrates mainly on the MRR components which is one of the critical components that affects the performance of the optical communication system.

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