SIMULATION AND PERFORMANCE ANALYSIS OF THE SUB CARRIER MULTIPLEXED RADIO OVER FIBER SYSTEM

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To my beloved mother and father

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ABTRACT

Radio over Fiber (RoF) technology or micro cellular over fiber is proposed solution for the reducing cost and providing highly reliable communication services. The system is a technique that modulates RF in microwave signals on an optical carrier to take advantage of the low loss of optical fiber characteristic. The RoF system is very cost-effective because the localization of signal processing in central station and also use a simple base station. In this system, the subcarrier multiplexed system for data transmission has been developed and the performance of the system was analyze in term of signal power, Bit Error Rate (BER), Carrier-to-Noise ratio (CNR) and Eye diagram. This system was focus on a link between two stations; a transmitter and receiver. The designed of SCM-RoF system employing PSK as the RF modulation scheme. In this work, the transmitter presenting four input signal and each of the signal will be modulate using PSK individually. At the optical domain, the CW Laser diode was used as the optical source, while Mach Zender as the optical modulator. Whereby, the transmission link was modelled using standard single mode fiber up to 150 km communication distance with EDFA 0m – 5m length. At the receiver end, the light carrying the radio subcarrier multiplexed signal is photo-detected by a PIN photodiode.

ABSTRAK

Teknologi penghantaran Radio melalui Fiber (*RoF*) telah memperkenalkan pengurangan kos dan penyediaan servis komunikasi yang boleh dipercayai. Sistem ini merupakan teknik memodulatkan isyarat frekuensi radio dengan isyarat pembawa optik dengan memanupulasi kelebihan kadar kehilangan yang rendah yang ada pada karakter fiber optik. Sistem RoF ini juga sangat kos-effektif kerana system ini manjalankan pemprosesan isyrat secara berpusat dan hanya memerlukan stesen utama yang ringkas. Sistem *subcarrier multiplexed* untuk sistem penghantaran data telah dibangunkan dan prestasi sistem ini telah dianalisi menerusi Kadar Ralat Bit (*BER*), Nisbah Pembawa dan Hingar (*CNR*) dan rajah mata. Sistem ini memfokuskan pengahantaran melalui satu penghantar dan satu pernerima. Sistem ini juga menggunakan PSK sebagai teknik memodulat isyarat. Pada kajian ini, empat saluran isyarat RF telah diperkenalkan yang mana setiap isyarat dimodulatkan dengan teknik PSK. CW laser telah digunakan sebagai sumber optik dan modulator Mach Zender digunakan sebagai modulator optik. Selain itu, Fiber satu mod (SMF) telah digunakan pada talian penghantaran dengan kadar jarak maksimum 150 km serta EDFA pada kadar 0 m – 5m. Pada bahagian penerima pula, pengesan optik PIN telah digunakan untuk mengesan isyarat termodulat tersebut.

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LIST OF SYMBOLS

f	:	Frequency
λ	:	Lambda
P_0	:	Input optical power
L_{is}	:	Insertion loss
φ_{Bias}	:	Bias phase shift
$V_{Л}$	:	Half wave voltage
θ_c	:	Critical angle,
Δ	:	Refractive index change
n_1	:	Refractive index
Er^{+3}	:	Erbium ion
J	:	Quantum number
dB	:	Decibel
N	:	Average number of electrons
T	:	Bit interval of time
m	:	Number of electrons generated
η	:	Quantum efficiency
ρ	:	Resistivity
Ω	:	Ohm
GHz	:	Giga Hertz

LIST OF ABBREAVIATIONS

TDM	:	Time Division Multiplexed
FDM	:	Frequency Division Multiplexed
SCM	:	Sub Carrier Multiplexed
WDM	:	Wavelength Division Multiplexed
SCM-ROF	:	Sub Carrier Multiplexed Radio over Fiber
CNR	:	Carrier to Noise Ratio
BER	:	Bit Error Rate
EDFA	:	Erbium Doped Fiber Amplifier
MZM	:	Mach Zehnder modulator
FM	:	Frequency modulation
AM-VSB	:	Amplitude modulation with vestigial sideband
IMD	:	Intermodulation distortion
ODSB	:	Optical Double Side Band
OSSB	:	Optical Single Side Band
SCM/WDM	:	Sub Carrier Multiplexed and wavelength-division multiplexing
LO	:	Local Oscillator
DFB LD	:	Distributed-feedback laser diode
ASE	:	Amplified Spontaneous Emission
PSC	:	Plastic-cladded silica fiber
PDG	:	Polarization Dependent Gain
LNA	:	Low noise amplifier
RMS	:	Root-mean-square

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CHAPTER 1

INTRODUCTION

1.1 Historical perspective

The technology of communication in huge bandwidth was the global demand either for industrial field or consumer interest. Basically, drastic demand of high bandwidth on communication was cause of a new communication application which required higher bandwidth such as internet video and audio and others new application. In recent years, optical communications networks are finally feeling the bandwidth constraints already in other type of communication networks such as wireless and satellite communication systems. In fact, service providers are searching a ways to increase their fiber optic network capacity.

Optical communication was one of the best ways in term of high bandwidth data communication. Even there a lot of parameters that will affect the performance of optical communication especially in term of dispersion and attenuation, server providers were have full of excitation to use optical fiber as medium. Technology like TDM, FDM, SCM and WDM and their combination are used and improved the performance of the optical communication.

The use of subcarrier multiplexing (SCM) transmission using an optical carrier instead of the traditionally used super carrier over optical fibers is very attractive. This technology has found wide spread application because of its simplicity and cost-effectiveness.

Error correction coding techniques, such a block convolution, and trellis, have advanced, further enhancing the noise immunity of multi state modulation scheme. Hus, the type of modulation mentioned plus coding techniques can be very good candidates for SCM application.

1.2 Project Background.

This project was focus on a link between two station; one transmitter and receiver. The link was applying SCM and Radio Over Fiber (ROF) system the schemes that has been applied to perform the communication system were PSK as a RF modulation techniques.

For this project, the transmitter has been focus only four input signal and each of the signal will be modulate using PSK individually. All the input signals so called as data signals has been multiplexed and allocated closely to each other. At the optical domain, the optical source was used CW Laser diode and Mach Zender modulator which is an external optical modulator. The composite signal (multiplexed signals) has been modulated with single optical wavelength by the MZM.

The transmission link has been replaced the typical transmission line (coaxial cable) with optical fiber. The system used a standard single mode fiber for long haul communication system which was able to exceed several kilometre. However, in this study, several components has been introduced or applied in the system such as optical amplifier which was post-amplifier and pump laser. Other than that, in the electrical domain, numbers of Band Bass Filter (BPF) has been applied at the transmitter and receiver part as well. In other to achieved better Carrier to Noise Ratio (CNR) of the system, electrical amplifier has been introduced after multiplexer and before demultiplexer.

At the receiver end, the light carrying the microwave subcarrier multiplexed composite signal is photo-detected by a photodiode. For this project, the system applies PIN as a photo detector at the receiver part.

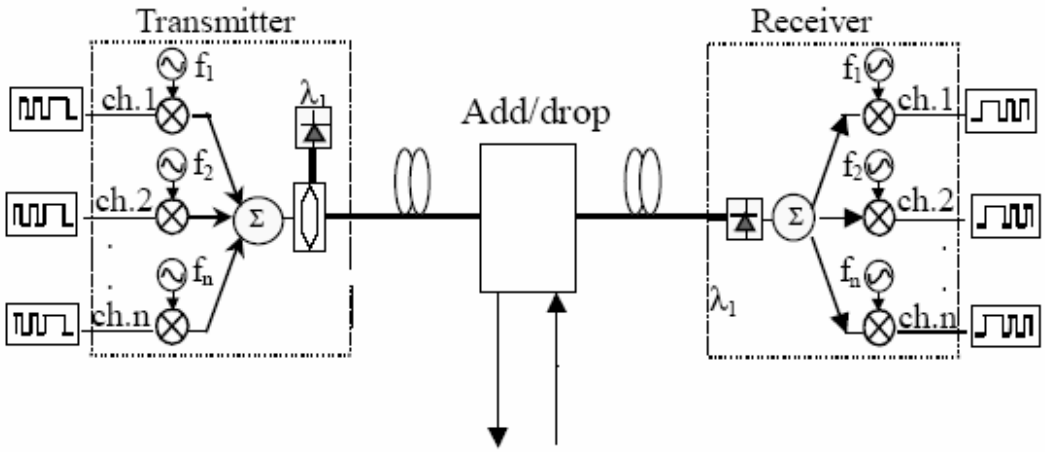

Figure 1.1: Basic architecture of a single end-to-end SCM system

1.3 Objectives

The objectives on this project are:

1) To model and simulate optical Sub Carrier Multiplexed – Radio over Fiber (SCM-ROF) System.

2) To analyze the performance of the SCM-ROF System in term of CNR, BER, Quality Factor, losses and attenuation.

1.4 Scope of Work

The scopes of this project are:

1) Modeled and analyzed specific to Sub Carrier Multiplexed – Radio Over Fiber System.

2) Completed a transmission system included single transmitter, optical link and single receiver.

1.5 Methodologies

The methodology of this project has been followed the list below and flow chart found in Figure 1.2

1) Full understand and literature review on current development of the optical system especially Sub Carrier Multiplexed – Radio over Fiber (SCM-ROF) System.

2) The system architecture has been identified and modeled.

3) The system has been modeled which was represented the connection from transmitter to receiver.

4) Suitable simulation software has been identified and applied to the system which was OptiSystem software.

5) The analysis of the system has been on to Fiber length without EDFA introduced, EDFA length, Fiber length with EDFA, nonlinearity due to optical power level, and number of channel in the system.

6) The system performances have been represented by the BER, CNR, Q Factor and eye diagram.

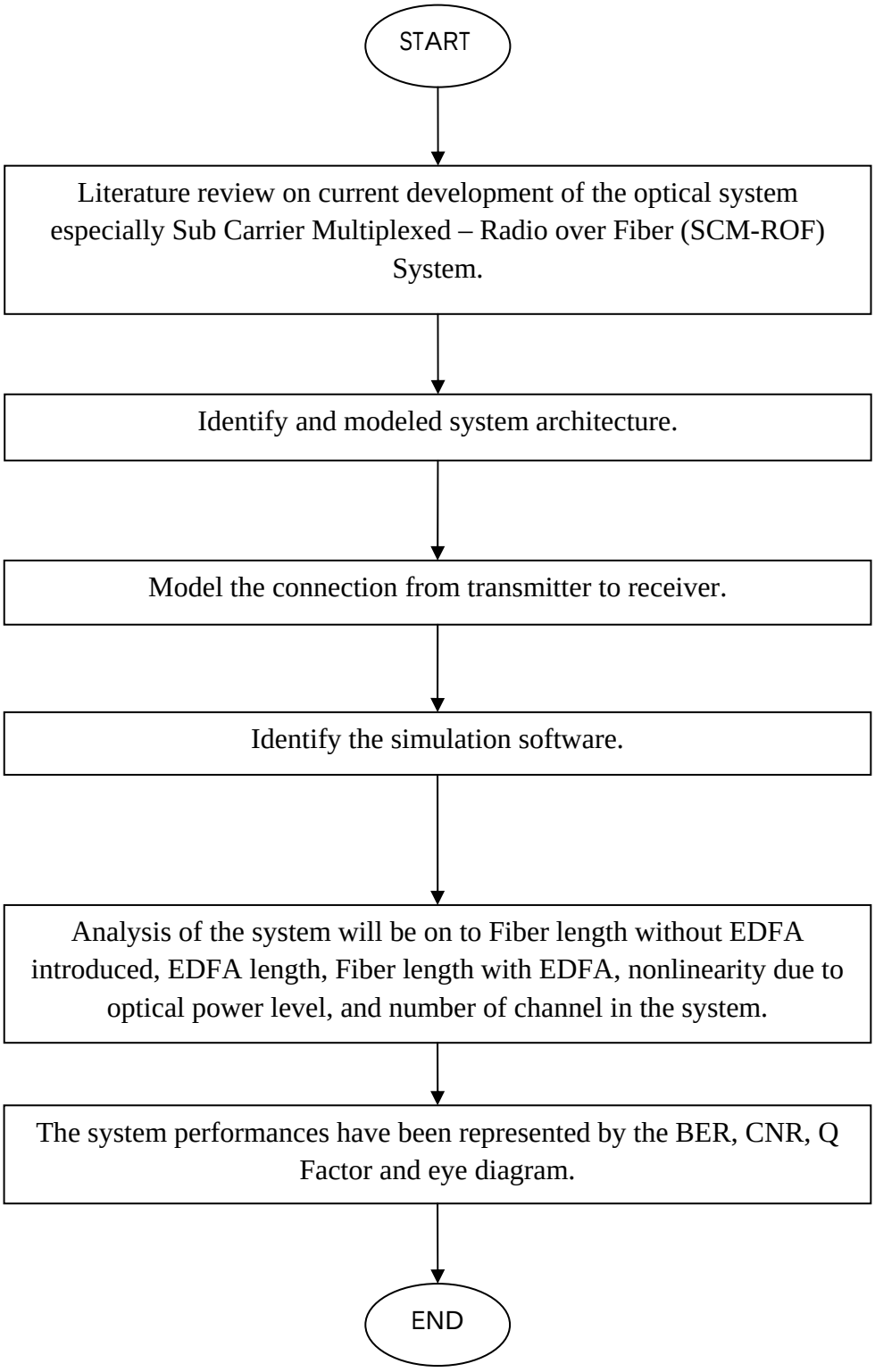

Figure 1.2: The project flow chart

The project has been following the basic outline that shows by the flow chart. However, there were several parameter need to be concern before shift one to another analysis. It was vital process especially that contributed the changes of frequency at the electrical domain and data rate of the incoming signals.

In addition, each of the components applied in the system has their own contribution in the system performance. Therefore, knowing the function, characteristic, response and also the parameters all the components was an obligation to the researchers before get through the simulation stage.

Last but not least, the performance analysis has been represented with suitable graphs, diagrams, and tables which were able to be referring for further study and the results compatible for some practical and industrial needs.

1.6 Thesis Outline

This project report is organized into 6 chapters which are introduction, literature review, SCM-ROF modeling, simulation results, performances analysis, conclusion and recommendation.

The first chapter will be discussed on the project background, scope of work and the methodologies applied in this project. In depth reviewed of the theoretical and previous study will be presented in the chapter 2 with literature review as the title. The reviewed will be cover from the basic knowledge of SCM system until to the

receiver part of the system. In chapter 3, the system of SCM-ROF will be discuss and describe the model for this project. In this chapter also presented the basic simulation setup from the modeled system. The simulation results will be presented and the issues involved will be explained in details in the chapter 4. These issues include general simulation method; simulation implementation of the modulations, optical fiber, and PMD issues. This chapter also presented the RF spectrum, electrical wave, eye diagram and optical spectrum for the system.

In chapter 5, the simulation results will be focused on five different of analysis of SCM-ROF system which was analysis on fiber length without EDFA introduced, analysis on EDFA length, analysis on fiber length with EDFA, analysis on nonlinearity due to optical power level, and analysis on number of channels in the system. These analyses will be presented the system performances by BER, CNR, Quality Factor and Eye Diagram as well.

And finally, in chapter 6, the thesis is concluded and the problems that need further studies are discussed and prospected. All publications paper also will be mentioned in this particular chapter.