

THE SUBCARRIER MULTIPLEXING/WAVELENGTH DIVISION
MULTIPLEXING FOR RADIO OVER FIBER

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ABSTRACT

In this project, we review the system configurations and performance of high-speed digital optical transmission using sub-carrier multiplexing (SCM) and Wavelength Division Multiplexing (WDM). The systems are setup to gain the performance of channels spacing especially for bandwidth efficiency and compare it by the modulation techniques. A radio-over-fiber (RoF) distribution system incorporating both SCM and WDM technologies is presented. In the system model, the sixteenth input signals are modulated with different electrical carriers at microwave frequencies and then they are merged by using a combiner. The combined of the signal is then modulated by external modulation techniques using Mach Zehnder Modulation that has own bandwidth is 20 GHz. In WDM, each of N different wavelengths is transmitting at N times the individual CW laser speed, providing a significant capacity enhancement. The WDM channels are separated in wavelength to avoid cross-talk when they are demultiplexed by a non-ideal optical fiber. In this scheme, multiple optical carriers are launched into the same optical fiber through the WDM technique. Each optical carrier carries multiple SCM channels using several microwave subcarriers. One can mix analog and digital signals using different subcarriers or different optical carriers. At the receiver end, the optical signal is converted back to an electrical domain by an APD photodetector and filtered by Bandpass Rectangle filter. The particular signals then demultiplexed and demodulated, using conventional detection methods. The outcomes of bandwidth was increased to 60 GHz by applying of 16 channel of SCM combined to WDM in optical fiber link. The combination of WDM and SCM provides the potential of designing broadband passive optical networks capable of providing integrated services (audio, video, data, etc.) to a large number of subscribers.

ABSTRAK

Didalam projek ini, kita mengkaji performance dan konfigurasi dari transmisi kecepatan tinggi optical digital menggunakan SCM yang dikombinasikan dengan WDM. Efisiensi lebar pita diperoleh dengan membandingkan teknik pemodulasi khususnya dari kanal - kanal di WDM. Sistem distribusi RoF dan teknologi SCM/WDM telah dikembangkan pada projek ini. Di dalam sistem ini, 16 sinyal input dimodulasi menggunakan pembawa sinyal elektrik yang berbeda, yang beroperasi pada frekuensi gelombang mikro, kemudian digabungkan menggunakan pengkombinasi sinyal. Sinyal yang telah dikombinasikan, dimodulasi kembali menggunakan sistem modulasi eksternal yaitu Mach Zehnder Modulator yang mempunyai lebar pita sebesar 20 GHz. Di sistem WDM, setiap dari N laser wavelength yang berbeda ditransmisikan dengan N, dikalikan kecepatan individual pada CW laser sehingga menghasilkan peningkatan kapasitas yang signifikan. Kanal – kanal dari WDM dipisahkan dalam *wavelength* dengan minimum jarak kanalnya adalah 50 GHz, hal ini diaplikasikan untuk mencegah terjadinya *cross-talk* ketika didemultiplek oleh filter optik non ideal. Dalam skema ini, pembawa sinyal – sinyal optik jamak ditransmisikan melalui kanal fiber optik menggunakan teknik WDM. Setiap pembawa sinyal optik dibawa oleh beberapa kanal SCM menggunakan *subcarrier* gelombang mikro. Pada sisi penerima, sinyal optik diubah menjadi sinyal elektrik yang diterima oleh detektor optik APD dan ditapis oleh filter *Band Pass Rectangular*. Sinyal yang telah diterima APD selanjutnya akan di demodulasi dan demultiplek dengan menggunakan teknik deteksi konvensional. Hasil dari penerapan sinyal input SCM sebanyak 16 kanal yang dikombinasikan dengan sistem WDM menghasilkan lebar pita sebesar 60 GHz. Kombinasi SCM/WDM merupakan teknologi yang paling potensial untuk dikembangkan untuk penyediaan komunikasi *broadband* yang meng-integrasikan layanan audio, data, video, dan lain – lain sehingga dapat meningkatkan kapasitas pelanggan dalam jumlah yang sangat besar.

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CHAPTER 1

INTRODUCTION

1.1 Historical Perspective

The prevalent utilization of Internet by business and consumer has been generating a global demand for huge bandwidth. In recent years, as new bandwidth hungry applications like internet video and audio and new access technologies such as xDSL become more popular, optical communications networks are finally feeling the bandwidth constraints already faced in many other communications networks such as wireless and satellite communication systems. Service providers are searching for ways to increase their fiber optic network capacity.

In order to solve this problem, people have been trying to make full use of the huge bandwidth provided by optical fibers. Technologies like TDM, CDMA, SCM, WDM and their combinations are used and improved.

One technology that can be used to increase the efficiency of bandwidth utilization is the Sub-carrier multiplexing (SCM). It is an old technology that has been studied and applied extensively in microwave and wireless communication systems.

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. In optical domain, the most popular SCM application is the optical analog video transmission and distribution.

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

Later, as technology advanced, WDM came along. The WDM strategy is to make better use of optical fiber bandwidth by stacking many TDM channels into the same fiber. Wavelength division multiplexing (WDM) is recognised as a key technology for increasing the capacity of distributive optical networks. To aid the design of such WDM systems, simulation tools are needed to provide for accurate synthesis and evaluation of proposed network architectures. Multichannel lighthwave networks present challenges in terms of how to most effectively represent multiple optical carrier signal formats and associated components and also with respect to performance evaluation in the presence of more complicated effects such as crosstalk.

1.2 Problem Statement

Recent years have seen enormous growth in the deployment of mobile phones and its service application. The revolution of mobile communication from the 1st generation till latest generation are shown the needed of mobile communication. Wireless access – fixed or mobile – is regarded as an excellent way to achieve broadband services. Of course, it is the only possibility for mobile access (in particular if global mobility is required), however wide application of fixed wireless broadband access is also foreseen.

The mobile communication architecture shown that evolution from 1G to the latest generation focused to efficiency and effectively of using frequency spectrum allocation. Due to the channel allocation (dispersion limitation) provides are limited. On the end-user side, the evolution are affected by enormous demand for services and content application for mobile communication, which users day to day their needed of easily communication, highly data rate and internet services, multimedia streaming application and spreadsheets processing for they mobile phone.

The oldest method of wavelength generation for the mobile application between the Mobile Switching Centre (MSC) and Base Station (BS) are using cooper cabling and microwave radio for data transceiver. In this system the spectrum allocation and bandwidth are required highest power, low data rate, highest attenuation and highly losses is not sufficient to overall the traffic demand by end-users.

It is well known that both due to unavailability of lower microwave frequencies and to the insufficient bandwidth of lower frequency ranges, next generation wireless access systems – both mobile and fixed – will operate in the upper

microwave/millimeter wave frequency band. As in a cellular system both increased traffic and propagation properties of millimeter-waves require small cells, further as millimeter-wave circuits are rather expensive, the cost of base stations (BSs) will be of determining role.

The main problems are dispersion limitation of the link. A radio-over-fiber (RoF) distribution system incorporating both sub-carrier multiplexing and wavelength division multiplexing (WDM) technologies is presented. This signal is directly modulated onto three high-speed lasers. Bragg filters are employed at the receiver base station in order to both demultiplex the required optical channel, and ensure that the detected signal is single side band (in order to overcome dispersion limitations of the link). System spectral efficiency is optimised by wavelength interleaving. The channel spacing between the WDM channels is varied and the system performance for different values of channel spacing and spectral efficiencies is investigated.

1.3 Objective

The main objective of this project is to increase radio channel allocation by using Sub-carrier Modulation/Wavelength Division Multiplexing techniques with the aimed of using fibre optic as part of an access link between the Mobile Switching Centre and the Base Station (BS).

The specific objectives are modeling and simulate optical Sub Carrier Multiplexing – Wavelength Division Multiplexing for Radio over Fiber (SCM/WDM -

ROF) System. To analyze the performance of the SCM/WDM-ROF System in term of distortion, channel spacing, Eye Diagram (BER), distortion and optical spectrum.

1.4 Scope of Work

Provide a proper study concerning channel allocation using Sub-carrier Multiplexing/Wavelength Division Multiplexing technique, the project begins with literature study and full understanding of the optical transmitter system (Laser Diode, SCM and WDM) and its characteristics. The literature concern on the SCM/WDM techniques in order to increased channel allocation and bandwidth.

The system will be simulated in Opti System Software, with special focused to the SCM/WDM characteristics. These characteristics will be modelled using by wavelength interleaving, the channel spacing between the WDM channels is varied and the system performance for different values of channel spacing and spectral efficiencies and the relatively Optical Single Side Band (OSSB), Optical Double Side Band (ODSB) which is the number of WDM channels are multiplexed are 4 x 4, 8 x 8 and 16 x 16 wavelength series (WDM).

1.5 Methodologies

The methodology of this project will follow the next flow chart:

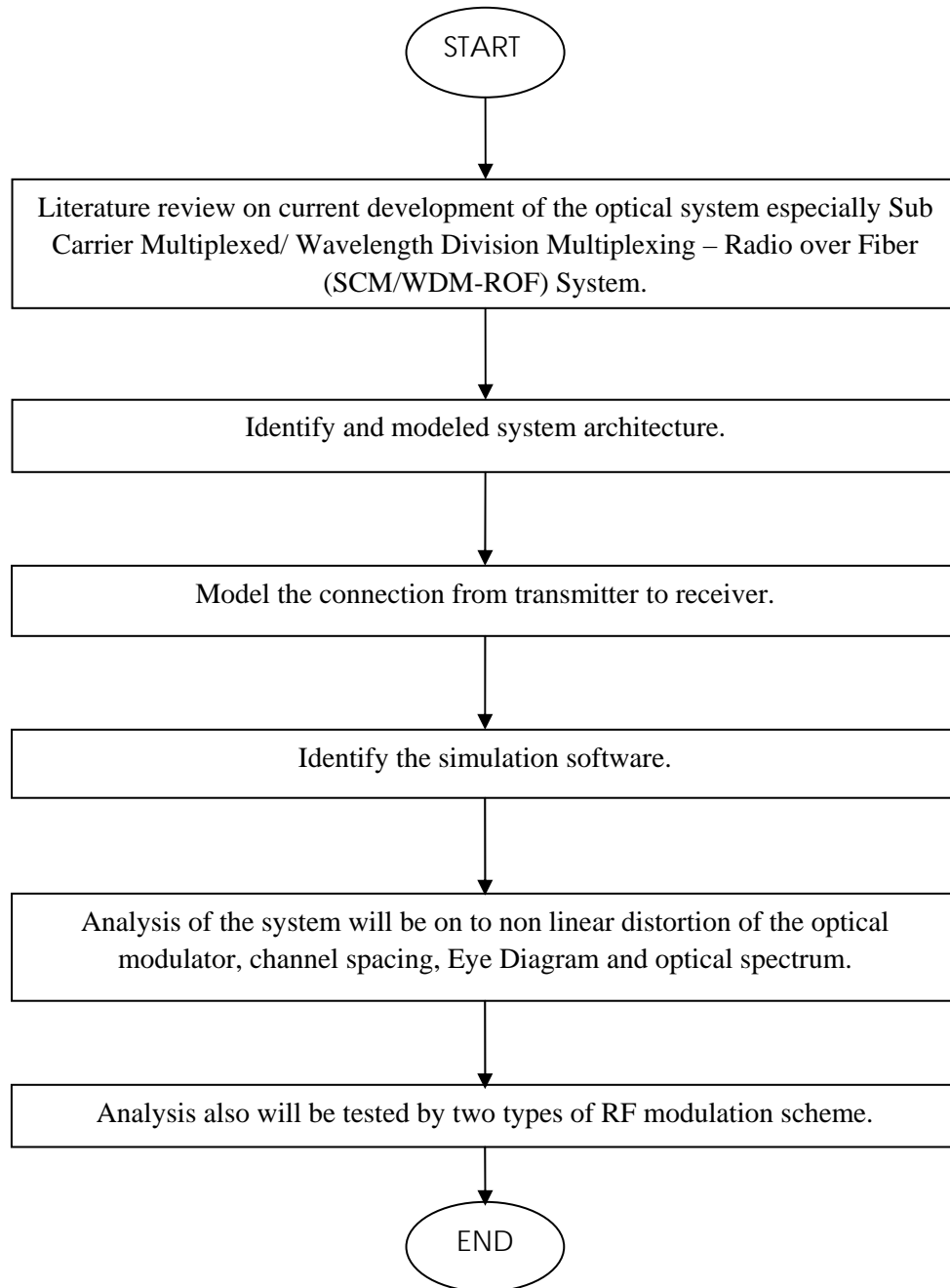


Figure 1.1: The methodology flow chart

First, full understand and literature review on current development of the optical system especially SCM/WDM for radio over fiber (RoF) system. After that we have to identified and modeled architecture system. Then the system will be modeled which represented the connection from transmitter to receiver. The choosing of suitable simulation software will be identified and applied to the system such as Opti System software. Next stage is analyzed of the system will be on to non linear distortion of the optical modulator, channel spacing, Eye Diagram (BER) and optical spectrum. And finally we have to apply of testing and measurements by the RF modulation scheme.

1.6 Thesis Outline

This project provides a theoretical model for radio over fibre technique. SCM/WDM are used to modelled the WDM channel spacing or channel allocation and bandwidth from the transmitter over optical fibre links (SMF/MMF) with the EDFA as an amplifier using comparative study of output-to-input approach. The main elements for this thesis were divided into 6 chapters.

Chapter 1 gives an introduction to the project, along with this aims, objective, and scope of work, problems statements, and methodology of this project.

Chapter 2 explains the general radio over fibre communication system and full understanding of the parts of optical transmitter elements, multiplexing techniques, wavelength, modulation techniques, and receiver components and their characteristics. Also this chapter are focuses on literature review for previous work relative to this project.

Chapter 3 review the characteristics of the wavelength transmission and the frequency channel limited allocation (dispersion limitation), bandwidth distortion in optical transmission medium and the techniques available to overcome it such as a sub-carrier modulation/wavelength dense multiplexing (SCM/WDM) techniques.

Chapter 4 are discusses the methodology of the project were the SCM/WDM technique and OPTIWAVE software are uses to model and implement the system is presented. In this chapter are proposed SCM/WDM with BPSK modulation system for radio over fibre which is using OSSB or ODSB and 4x4 WDM, 8x8 WDM, 16 x 16 WDM for channel multiplexer is presented.

Chapter 5 discussed the modelling of the radio over fibre using SCM/WDM and presents the performance analysis of the plotted graph after implementing the model in OPTIWAVE software.

Chapter 6 focuses the conclusion of the results and how far the overall objectives were achieved. This chapter also provide the recommendation future development and modifications of the findings.

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