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Simulation of RoF Using Wavelength Selective OADM

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Abstract: *Radio over Fiber (RoF) is an analog optical link transmitting modulated RF signals. It serves to transmit the RF signal downlink and uplink, to and from central station (CS) to base station (BS) also called as radio ports. Optical add-drop multiplexer (OADM) is a device used in wavelength division multiplexing systems for multiplexing and routing different channels of light into or out of a construction of optical network. A wavelength selective OADM that uses FBG as wavelength selective filter is being proposed. The OADM proposed in this paper can select the wavelength that is to be dropped.*

Keywords: *Radio over Fibre, Wavelength Division Multiplexing, OADM.*

1. Introduction

Radio over Fiber (RoF) is an analog optical link transmitting modulated RF signals. It serves to transmit the RF signal downlink and uplink, to and from central station (CS) to base station (BS) also called as radio ports [2]. The main requirements of radio over fiber link architecture are duplex operation (downlink-uplink), reasonable length (a few tens of kilometers), need a few millimeter-wave components only in the base stations and also need of only few high-performance optical components. RoF systems are now being used extensively for enhanced cellular coverage inside buildings such as offices, shopping malls and airport terminals. It has emerged as a cost effective approach for reducing radio system costs because it simplifies the remote antenna sites and enhances the sharing of expensive radio equipment located at appropriately sited switching centers or central stations. The frequencies of the radio signals distributed by RoF systems span a wide range (usually in the GHz region) and depend on the nature of the applications. In our proposed system we are using wavelengths which fall under C-Band (1525-1565nm), which is also known as “conventional” or “erbium window”. The window which is around 1500 nm is most widely used, as this region has the lowest attenuation losses and hence it achieves the longest range.

On the basis of wavelength division multiplexing (WDM) and optical add/drop multiplexing (OADM) a full duplex data and video signal is transmitted over a single mode fiber (SMF) [3]. This paper proposes a wavelength selective OADM that uses FBG as wavelength selective filter so that the wavelength to be dropped can be selected. In this work, the simulation of the system is done in two sections. In the first section, optimization of different electrical encoding methods (Gaussian, RZ and NRZ coding) and different optical modulation schemes (Electro absorption modulation, Mach-Zehnder Modulator and Phase modulator) were analyzed. Also fiber length was optimized for transmission. Different fiber lengths were tested and analyzed. Also characterization of different components like WDM and OADM were performed. In the second section the proposed system is simulated using the optimized components. The performance of the system is analyzed using Optisystem tools like BER analyzer, Eye Diagram, Optical Spectrum Analyzer.

The rest of the paper is organized as follows. A description about the optimization of system components is given in section 2. Section 3 gives the simulation of the proposed system. Results and analysis of the system is described in section 4, followed by the conclusion.

2. Optimization of System Components

In this section optimization of different electrical encoding methods (Gaussian, RZ and NRZ coding) and different optical modulation schemes (Electro absorption modulation, Mach-Zehnder Modulator and Phase modulator) are analysed. Also fibre length is optimized for transmission. Different fibre lengths are tested and analysed. Also characterization of different components like WDM and OADM are performed.

2.1. Optimization of Electrical Encoding Methods

The electrical encoding methods analyzed here are Gaussian, NRZ coding and RZ coding. These electrical encoding methods are tested for different lengths of the fiber. It was found that for a fiber length of 40kms NRZ coding has a BER of the order of 10^{-37} as shown in fig. 1.

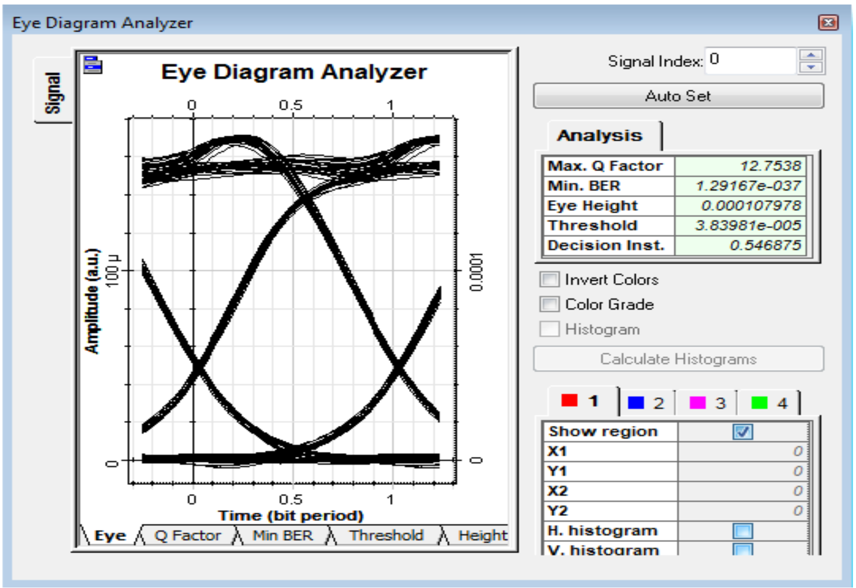

Fig1. *Eye Diagram for NRZ Coding*

2.2. Optical Modulations

The optical modulators analysed in this work are electro absorption modulator, Mach-Zehnder modulator and phase modulator and also these are tested for different lengths of the fibre. From the eye diagram it is found that EAM has a BER of the order of 10^{-90} for a fibre length of 40kms. The

Eye diagram for EAM is shown in fig. 2.

2.3. Wavelength Division Multiplexing

In fibre- optic communications, wavelength-division multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. The term wavelength-division multiplexing is commonly applied to an optical carrier (which is typically described by its wavelength), whereas frequency-division multiplexing typically applies to a radio carrier (which is more often described by frequency) [4]. Fig. 3 shows WDM operating principle.

The use of WDM for the distribution of RoF signals has gained importance. WDM enables the efficient exploitation of the fiber network's bandwidth. Its application in RoF networks has many advantages including simplification of the network topology by allocating different wavelengths to individual BSs, enabling easier network and service upgrades and providing simpler network management.

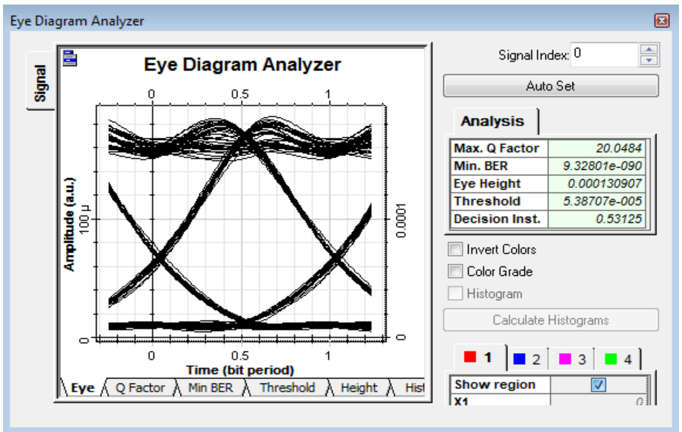

Fig2. *Eye Diagram for EAM Modulator*

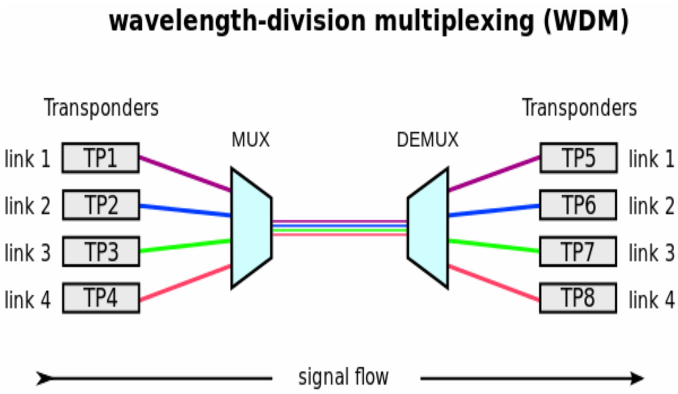

Fig3. *WDM Operating Principle Modulator*

2.4. Optical Add-Drop Multiplexing

Optical add-drop multiplexer (OADM) is a device used in wavelength division multiplexing systems for multiplexing and routing different channels of light into or out of a construction of optical network as shown in fig. 4[2]. Add and drop here refer to the capability of the device to add one or more new wavelength channels to an existing multiwavelength WDM signal, and to drop one or more channels, passing those signals to another network path. An OADM may be considered to be specific type of optical cross connect. A traditional OADM consists of an optical demultiplexer, an optical multiplexer and between them a method of reconfiguring the paths between demultiplexer, multiplexer and a set of ports for adding and dropping signals. Physically, there are several ways to realize an OADM.

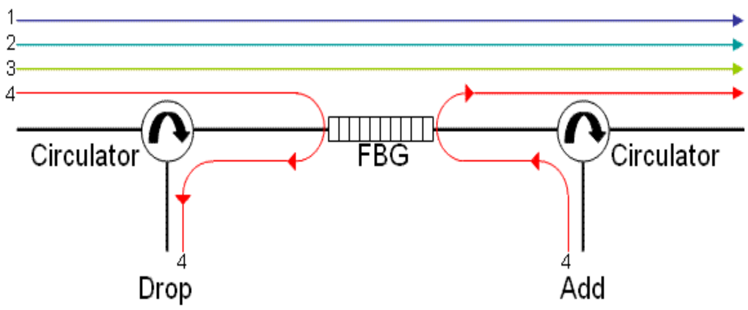

Fig4. *OADM Using Fibre Bragg Grating and Two Circulators*

3. Simulation of Proposed System

In this work, a wavelength selective OADM is proposed and simulated. For downlink transmission, the central station is composed of two 2-tone video signals that are amplitude modulated and two data signals. The first AM modulated video signal is obtained by combining 500MHz and 525MHz, whose scope image is shown in fig. 5. The second AM modulated video signal is obtained by combining 600MHz and 675MHz, whose scope image is shown in fig. 6. Fig. 7 shows the layout of the proposed wavelength selective OADM consisting of two circulators and a Fiber Bragg Grating (FBG).

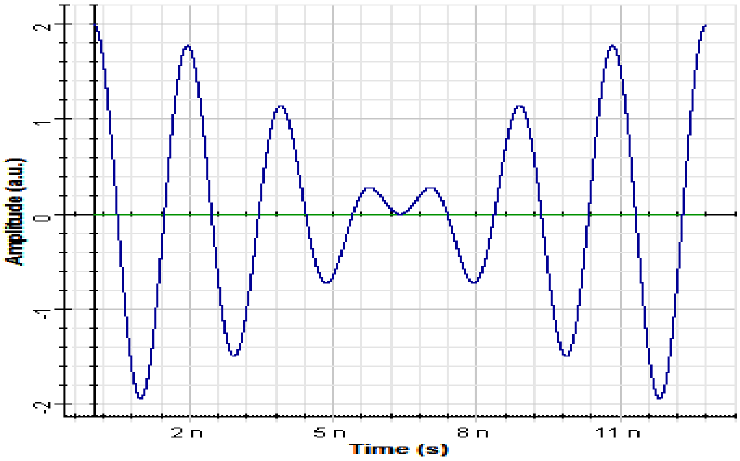

Fig5. *Scope Image of 500-525MHz Video Signal*

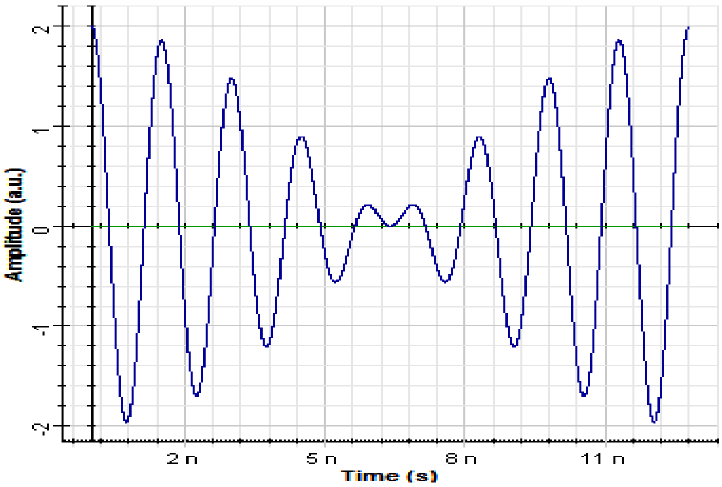

Fig6. *Scope Image of 600-675MHz Video Signal*

In addition to the video and data signals, the central station consists of four continuous wave (CW) lasers, two EAM modulators, two Mach-Zehnder (MZ) modulators, erbium-doped fiber amplifiers and wavelength division multiplexers. The carrier wavelengths used here are 1546nm, 1548nm, 1550nm and 1552nm. Fig. 8 shows the block diagram for our simulation model.

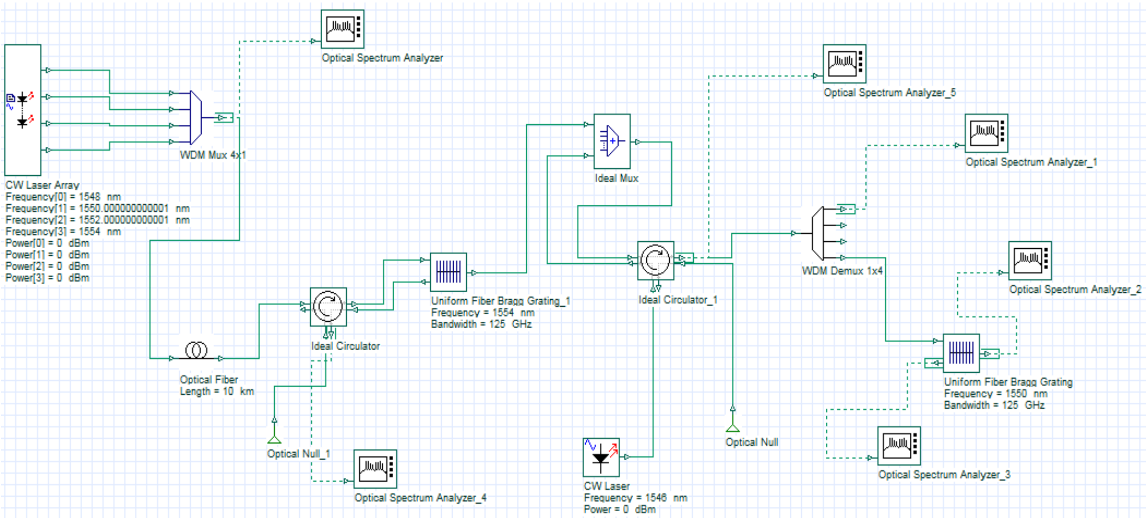

Fig7. *Layout of the Proposed OADM*

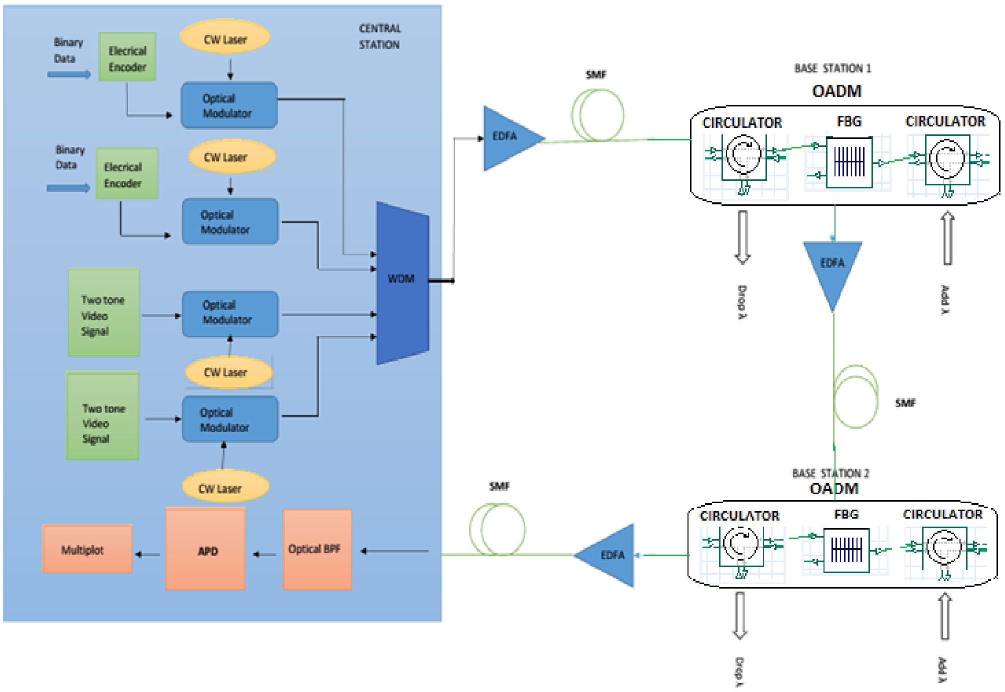

Fig8. *Simulation Model Block Diagram*

The system consists of two binary data's that are electrically encoded using NRZ coding to convert it into electrical signals. The two data signals are optically modulated using EAM modulator and the two 2-tone video signals are modulated using MZ- modulator. All these signals are then multiplexed using WDM and it is then amplified using EDFA and transmitted through the fiber transmission link. EDFA length is 1.5m. Beyond this length, the gain causes distortions for both video and data signals. The fiber length is optimized to be 30km.

At the transmitter end, after transmission through the WDM there will be four wavelengths, that is, 1546(video), 1548(data), 1550(video) and 1552(data). All these have a power of 2mW. At the first base station (BS1), that is the OADM, the FBG reflects 1548nm (data). This wavelength is reflected back to the circulator where it is directed down and dropped. Since 1548nm gets dropped, another wavelength 1544nm (data) gets added. So after BS1 transmission the wavelengths transmitted to the second base station (BS2) will be 1544nm (data), 1546nm (video), 1550nm (video) and 1552nm (data). At BS2 the same procedure repeats. Here 1550nm (video) signal gets dropped and 1554nm (video) gets added. Then after BS2 transmission, the signals are passed through optical BPF and to PIN detector to demodulate the electrical signals. At the receiver the signals obtained are 1544nm (data), 1546nm (video), 1552nm (data) and 1554nm (video).

4. Results and Analysis

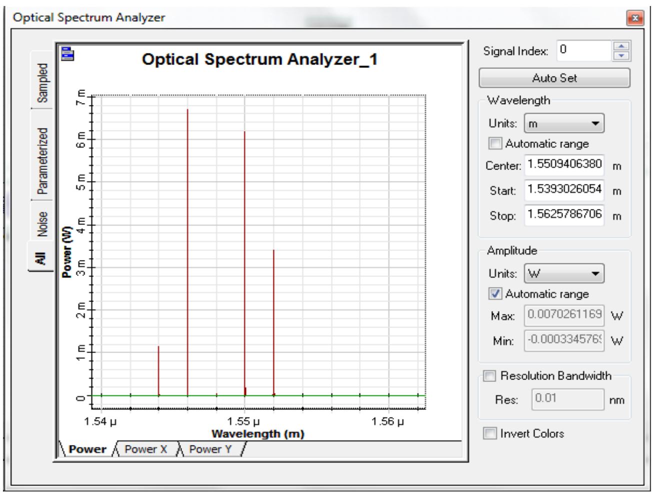

Fig9. *Signal Spectrum at BS1*

Simulation is done using the simulation software Optisystem. The spectrum of signals at BS1, that is, 1544nm (data), 1546nm (video), 1550nm (video) and 1552nm (data) is shown in fig. 9. Fig. 10 shows the spectrum at BS2, that is, 1544nm (data), 1546nm (video), 1552nm (data) and 1554nm (video).

The eye diagram at the receiver shows a BER of the order of 10^{-12} and is shown in fig. 11.

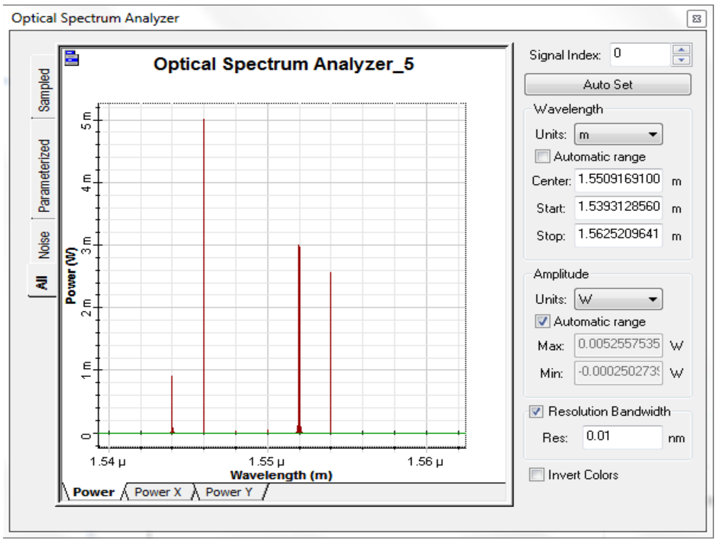

Fig10. *Signal Spectrum at BS2*

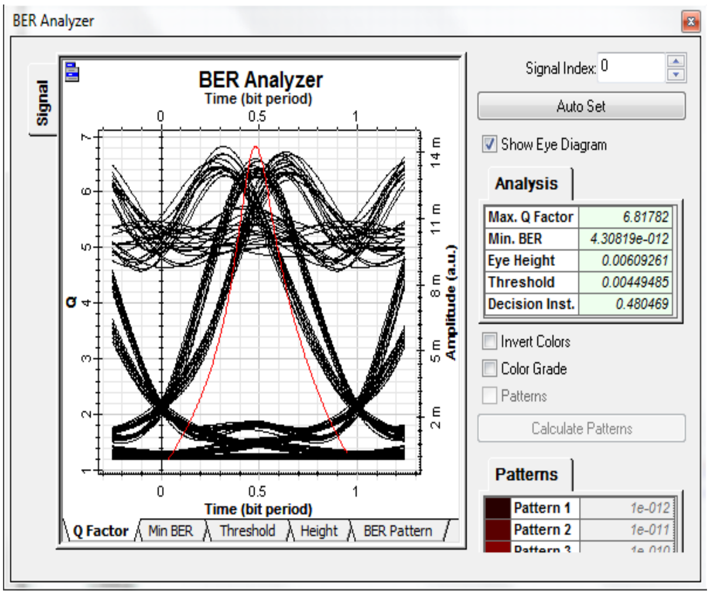

Fig11. *Eye Diagram at the Receiver*

5. Results and Analysis

A wavelength selective OADM is proposed and simulated. The simulation is done in the simulation software Optisystem. The wavelength selective OADM uses FBG as wavelength selective filter. The OADM proposed in this paper can select the wavelength that is to be dropped. It is found that for a fibre length of 40kms NRZ coding has a BER of the order of 10^{-37}. From the eye diagram it is found that EAM has a BER of the order of 10^{-90} for a fibre length of 40kms.The eye diagram at the receiver shows an acceptable BER of the order of 10^{-12}.

Acknowledgement

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