A Wide FBG-Based Optical Clock and Data Recovery for Optical Access Networks

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A Wide FBG-Based Optical Clock and Data Recovery for Optical Access Networks

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ABSTRACT

All-Optical Clock and Data Recovery (OCDR) is considered the most promising technique to increase the optical networks distance and the data rate by synchronizing and regenerating the data along the fiber cable, consequently achieving small Bit Error Rate (BER) at the receiver end. In this paper, we design and implement the OCDR using two different techniques, Self-Pulsating (SP) using Distributed Bragg Reflector laser (DBRL) and Filtering based using Fiber Brag Grating (FBG). A comparative study and measurement of the network performance for the two methods have been presented. The experimental results show clearly the increase either transmission distance or the bitrate.

Keywords: Optical Clock and Data Recovery, Optical Network, Fiber Brag Grating, Self-Pulsating Laser, Distributed Bragg Reflector Laser.

1. INTRODUCTION

Optical Clock and Data Recovery (OCDR) solution is considered the most promising technique to increase the optical network distance and the data rate. OCDR can expand the transmission distance by synchronizing, and reshaping the data along the optical fiber. Consequently the presence of the OCDR achieve small Bit Error Rate (BER) at the receiver end [1][2]. Several methods are used to implement the OCDR such as: quantum dash lasers [3], self-pulsating lasers [4] and passive filtering techniques [5][6].

2. ARCHITECTURE IMPLEMENTATION

In this section, we present a complete design and implementation of two different types of OCDR, Distributed Feedback Laser (DBR) based on Self-Pulsating Laser and Fiber Bragg Grating (FBG) based on filtering technique. All the simulation has been done using Optisystem tools. Optisystem is a comprehensive software design suits that enables users to plan, test, and simulate optical links in the transmission layer of modern optical networks [7].

2.1 Basic Concepts and Definitions

Fiber Bragg Grating (FBG) Filter is shown in Fig. 1 (a) is a type of optical filter. It is a distributed Bragg reflector constructed in a small part of optical fiber that reflects particular wavelengths of light and transmits all the others. This Occurred by creating a periodic variation in the refractive index of the fiber core. A FBG can therefore be used as optical filter to reject certain wavelengths, or as a wavelength-specific reflector [8].

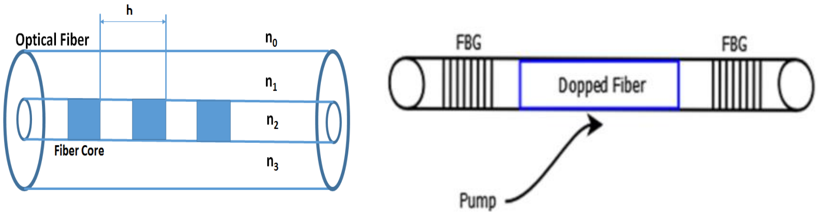

Figure 1. Structure of (a) Optical Fiber Bragg Grating Filter (b) Distributed Bragg Reflector (DBR) Laser

Distributed Bragg Reflector Laser (DBRL) Distributed Bragg Reflector (DBR) Laser is shown in Fig. 1 (b). It consists of two Fiber Bragging Gratings (FBGs), separated by eribium dopped fiber. The FBG has a periodic structure from multiple layers with varying refractive index to reflect a desired wavelength. The doped fiber feeds with pump laser and operates as an amplification medium [9].

2.2 OCDR Filter-based using Fiber Bragg Grating (FBG) Filter

The implemented architecture of OCDR using FBG filter shown in Fig. 2. It consists of two optical sources with different wavelengths; one is modulated by the electric signal which is generated by a random bit generator, and the other is modulated by the clock information. The modulated optical signals are multiplexed by using WDM multiplexing (WDM-MUX) and then injected into a fiber cable that has a variable length from 500 m to 30 km. When the signal reaches the receiving end, it divides into two branches. One sends directly to PD, LPF and later to OSC1, and the other forewords to the OCDR which consists of dispersion compensation fiber (DCF), two FBG filters, circulator, optical amplifier and optical bandpass filter OBPF, then the signal output of the OCDR directs to PD, LPF and then finally to OSC2.

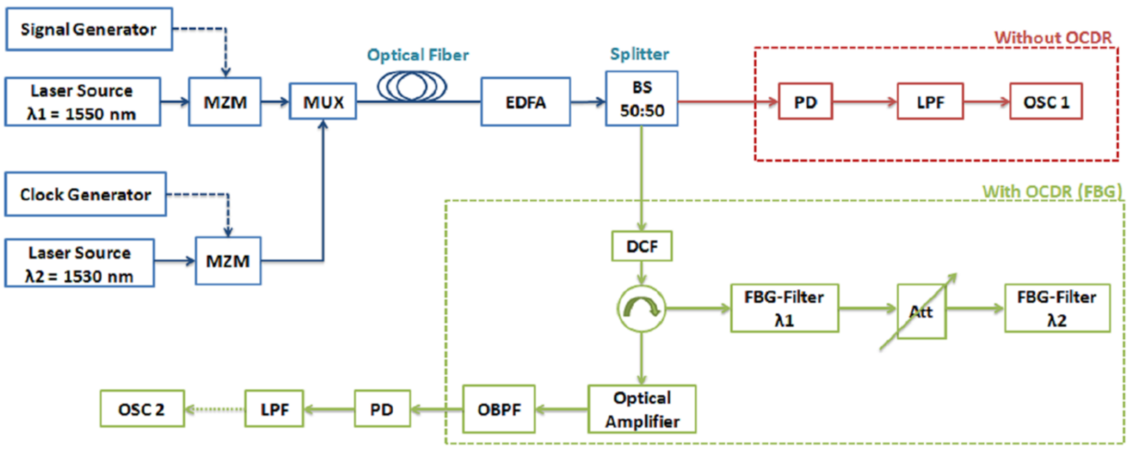

Figure 2. The Proposed Architecture for OCDR Filter-Based using FBG Filter

MZM: Mach-Zehnder Modulator, EDFA: Erbium Doped Fiber Amplifier, PD: Photo Detector, LPF: Low Pass Filter, DCF: Dispersion Compensation Fiber, FBG: Fiber Brag Grating, OBPF: Optical Band-Pass Filter, Att: Optical Variable Attenuator

2.3 OCDR using Distributed Bragg Reflector Laser (DBRL)

The block diagram of OCDR using DBRL is shown in Fig. 3. In this architecture, the Mach-Zehnder Modulator (MZM) modulates the received optical beam from laser source with an electric signal generated by the random bit generator which generates a data with bitrates from 10 Gb/s to 40 Gb/s. The modulated output is directed to an optical fiber with variable length from 500 m to 50 km. At the receiving end, the incoming optical signal is split by using a 50:50 splitter. One part sends to Photo Detector (PD) through an optical amplifier and optical band-pass filter (OBPF) which converts the optical signal to corresponding electrical signal. The converted signal is filtered by using Low Pass Filter (LPF) has a band width equal to 0.75 bitrate and then forwards to the oscilloscope (OSC1). The other part forwards to the OCDR which consists of Dispersion Compensator (CD), two FBG filters, and EDF which is pumped by laser source of wavelength 980 nm and power equals 1mw. The recovered optical signal directs to the second oscilloscope (OSC2) after it passes through PD and LPF.

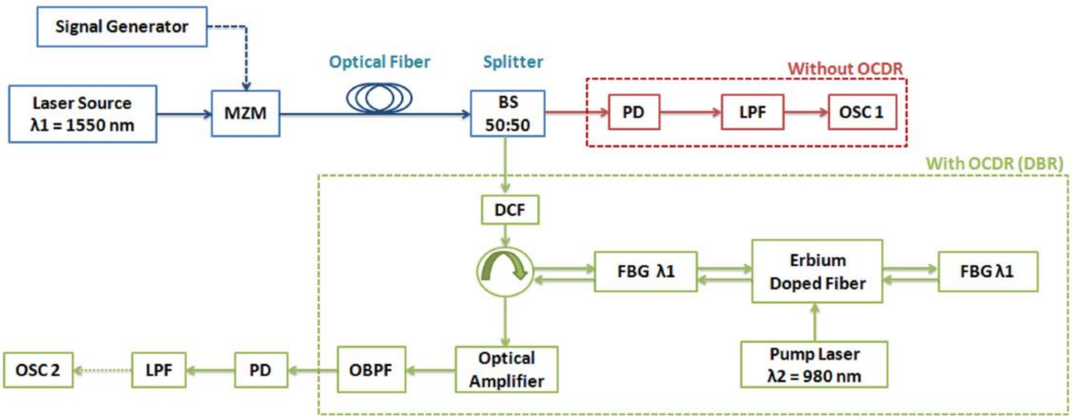

Figure 3. The Proposed Architecture for OCDR Self-Pulsating Laser using DBRL

MZM: Mach-Zehnder Modulator, EDFA: Erbium Doped Fiber Amplifier, PD: Photo Detector, LPF: Low Pass Filter, DCF: Dispersion Compensation Fiber, FBG: Fiber Brag Grating, OBPF: Optical Band-Pass Filter, OSC: Oscilloscope

3. RESULTS AND COMPARISONS

In this section, we simulate the proposed architectures and study the effect of changing the bitrate and the fiber length parameters on the performance using OptiSystem simulation tools. Figures 4 (a) and (b) plot the minimum log BER as a function of the fiber length for bitrates 10 Gb/s. We can observe that for BER equals 10^{-2} the transmission distance is increased twice if we are used self-pulsating method instead of fiber-based. Thus, the proposed OCDR architecture using DBRL is improved the transmission distance comparing to the architecture is used the FBG filter.

As shown in Fig. 5, the BER is calculates for the two proposed architectures under different values of bitrate (10 Gb/s to 40 Gb/s). As we can see, the performance of OCDR based of DBRL is better than the OCDR based on FBG filter.

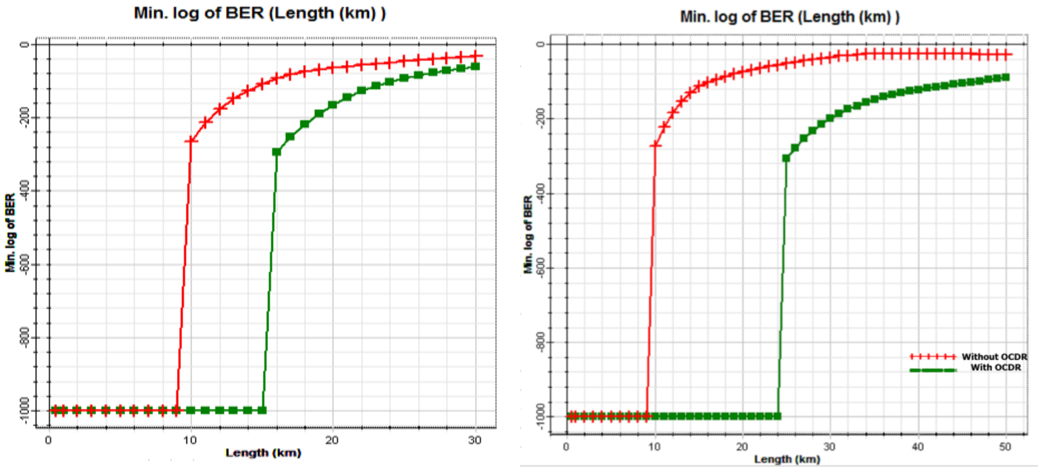

Figure 4. BER versus transmission distance for OCDR using (a) FBG (b) DBRL at 10Gb/s

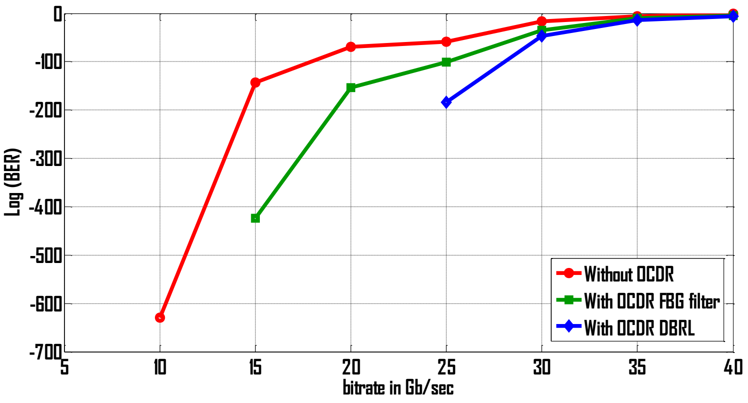

Figure 5. BER versus bitrate at transmission distance = 10km

A numerical analysis for the comparative study between the two architectures with different bitrates and transmission distance is summarized in Table I.

Table I: The transmission distance at BER 10^-2 for bitrate 10, 25 and 40 Gbps

Bitrate	10Gbps	25 Gbps	40 Gbps
Without-CDR	16 km	3 km	1 km
FBG-Filter	24 km	4 km	1 km
DBRL	46 km	8 km	5 km

4. CONCLUSIONS

In this paper, FBG filter and DBRL have been used in implementing two types of high-speed and low-cost OCDR for optical access network. The results from this work are shown that the performance achieved by the proposed architectures is improved the system performance while increasing either the transmission bit rate or the distance.

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