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Adaptive Performance Improvement of Fiber Bragg Grating in Radio over Fiber System

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Abstract

The combination of Radio Frequency and Optical Fiber has resulted high capacity transmission at lower costs components and makes Radio over Fiber as a current trend of large broadband communication. In Fiber optics field, the use of Fiber Bragg Grating (FBG) was been proposed in recent research with different purpose of uses. However, the compensation of dispersion method of Fiber Bragg Grating (FBG) can boost significantly the system performance. This paper investigates the performance capacity improvement of adaptive Radio over Fiber system. The system design was performed using OptiSystem 7.0 software, which 10 Gb/s Non Return to Zero (NRZ) signal was launched into 50 Km Universal Mode Fiber and Fiber Bragg Grating was used as a compensator of dispersion before frequency up conversion. Therefore, the system performances were investigated by comparing the Bit Error Rate (BER) and Q-factors of Positive Intrinsic Negative (PIN) and Ultrafast Avalanche Photodiode (APD) as optical receivers. The Eye diagram analyzer showed acceptable improvement due to use of Fiber Bragg Grating as a compensator of dispersion.

Keywords

Radio over Fiber (RoF), Fiber Bragg Grating (FBG), Dispersion Compensating Fiber (DCF), Positive Intrinsic Negative (PIN), Ultrafast Avalanche Photodiode (APD)

1. Introduction

Radio over Fiber is becoming increasingly important for wireless communication in order to support the big data traffic volumes. Currently the integration of Radio Frequency and optical fiber provide enormous bandwidth and reduce significantly the power consumption compared to the others technologies.

Dispersion compensating fiber (DCF) is currently used as the standard solution for dispersion compensation in long distance transmission, since it matched the dispersion cancellation with negligible cascading impairments [6]. However the transmission of light over Dispersion compensating fiber component is limited due to input power to avoid nonlinear impairments that create a high insertion loss over the link. Therefore, Chirped

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Fiber Bragg Grating (FBG) possibly replaces DCF as a standard solution for line dispersion compensation.

Fibers Bragg Grating (FBG) has negligible nonlinearity, low insertion loss and small size sits can possibly impact the system performance and boost the network capacity when used in two different scenarios methods either as a dispersion compensator for long distance fiber network or when used for routing wavelength in Wavelength Division Multiplexing (WDM) systems. In both areas, Fiber Bragg Grating can easily impact the system performance especially when the grating is chirped [1]. The highly selective filtering capabilities of Fiber Bragg Grating combined with its all fiber configuration and flexibility make this technology an ideal candidate for the current and next generation networks [2].

The dispersion compensation of FBG has been demonstrated over 72 Km fiber link leading to error free transmission of 10 G/bit signal in [3] and also the feasibility of long haul Wavelength Division Multiplexing optical transmission using Fiber Bragg Grating.

This paper investigates the performance improvement of Fiber Bragg Grating in adaptive Radio over Fiber system as considered in [1] and [3]. The scenario solution of long distance link, WDM-RoF system was considered since Radio over Fiber offers lower attenuation loss, better coverage and increased capacity and also is also resistant to Radio Frequency Interferences. The section II discusses the propose work regarding the dispersion compensation using FBG configuration in adaptive Radio over Fiber system.

2. Proposed System

The chromatic dispersion is a major issue in the Single Mode Fiber when the signals are transmitted over long distance. The main raison of the proposed system model was to analyze the performance of Fiber Bragg Grating as a compensator of dispersion in Radio over Fiber system. In the system designed, the 10 Gb/s Non Return to Zero (NRZ) signal was launched onto 50 Km using Single Mode Fiber (SMF) and the power splitter was used to split the signal into four channels before the frequency up conversion. PRBS (Pseudo Random Bit Sequence) generates the Sequence of Bit Radom. The optical Mach Zehnder Modulator (MZM) was used to modulate the optical source and frequency data together. The continuous wave (CW) was used to provide optical carrier with responsively of 1 W as illustrated in **Figure 2**. The optical signal was transmitted over 50 Km Universal single mode fiber and amplified up to 20 dB due to loss power over long distance transmission. Therefore, at the receiver part the use of power splitter was to split the input signal into four optical signal output. These optical signals are then passed through the optical band pass filters to select the wavelength in frequency of 10 GHz.

The use of Fiber Brag Grating in the system proposed in **Figure 1** is for compensate the dispersion effect of adaptive Radio over Fiber over long distance transmission.

3. Simulation and Discussions

The system designed was performed using OptiSystem software version 7.0. The **Figure 2** and **Figure 3**, demonstrated the performance improvement of Fiber Brag Grating when the line of dispersion was compensated at the Optical receivers. Therefore, at the receivers the results output was validated by analyzed the Q-factor and Bit Error Rate of two different optical detectors with and without using Fiber Bragg Grating device.

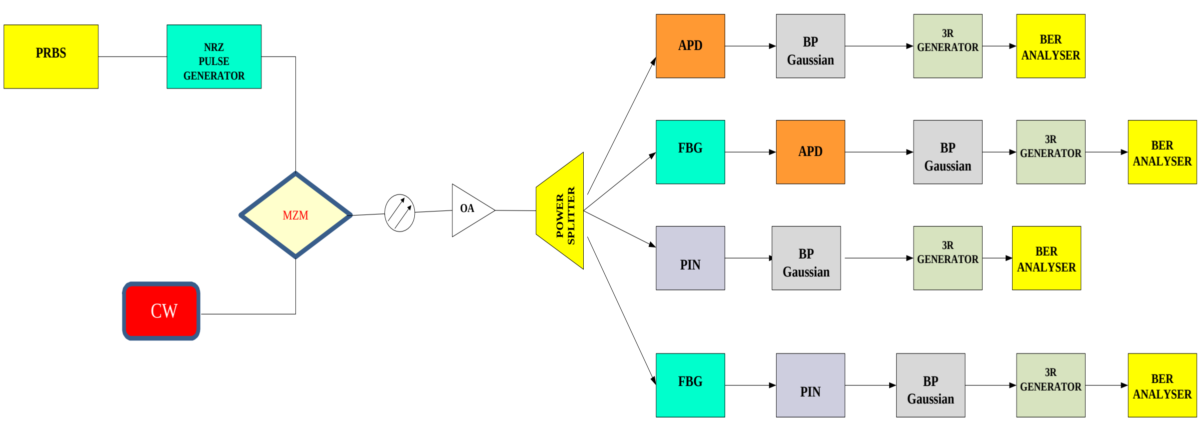

Figure 1. Block diagram of our proposed Adaptive RoF system with FBG.

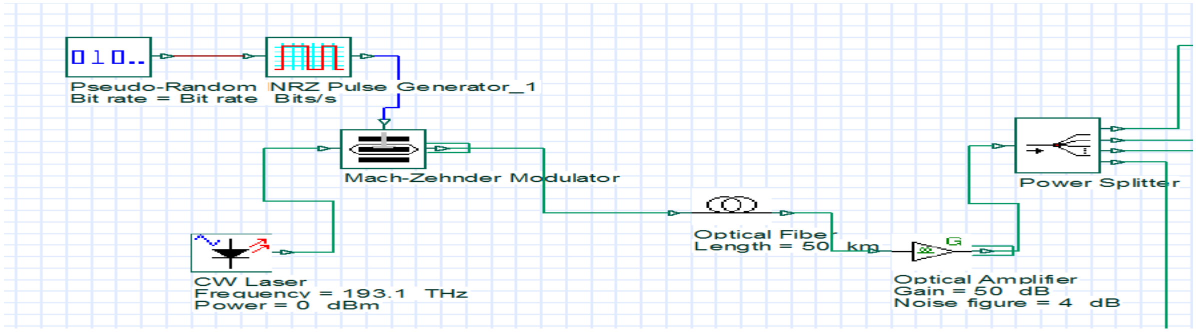

Figure 2. Simulation schematic of RoF transmitter part.

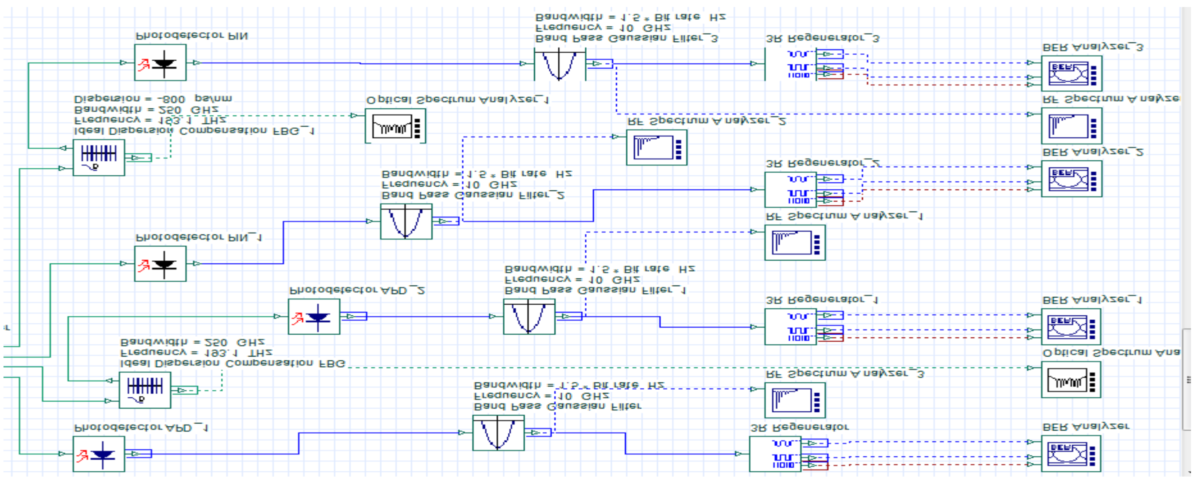

Figure 3. Simulation schematic of RoF receiver part with fiber Bragg grating.

In this paper, the simulation approach was performed in two methods, the first was to employ an Ultrafast Avalanche Photodiode (APD) and the second was to employ Positive Intrinsic Negative (PIN) for comparing the output results of both receivers. The results were evaluated using tree types of analyzers such as optical spectrum analyzer, electrical spectrum analyzer and Bit Error Rate analyzer.

Figure 4(a) presents the results output of system based on the eye diagram analyzer of Electrical signal before employing FBG as compensator of dispersion. Furthermore, **Figure 4(b)** illustrates the Electrical signal output after compensation made by FBG with PIN as optical receiver. Moreover, **Figure 5(a)** and **Figure 5(b)** illustrate the Electrical signals spectrum before and after using Fiber Bragg Grating as compensator of dispersion with APD at the receiver. The results of Ultrafast Avalanche Photodiode (APD) and Positive Intrinsic Negative (PIN) as the receivers are shown in **Table 1** and **Table 2** respectively. The resulting output of the BER analyzer shows the significant improvement when APD was used with FBG on the channel. Moreover, when PIN was used as receiver, the eye diagram has improves by 5 times as illustrated in **Figure 4(a)** and **Figure 4(b)** when the results was compared with and without FBG. Therefore, when APD was used at the receiver, the Q-factor was improved by a factor close to 8 times as illustrated the **Figure 5(a)** and **Figure 5(b)** before and after compensation made by FBG. The simulation result shows the acceptable performance improvement of the adapting Radio over Fiber using FBG as a compensator of dispersion.

4. Conclusion

In this paper we analyzed the adaptive performance of Fiber Bragg grating as a compensator of dispersion effect over Radio over Fiber system. Here, some electronic components have been eliminated such as the need of electrical modulator and optical demultiplexer has replaced by power splitter, which reduce considerably the cost and complexity of system. In the proposed system, optical signal was directly converted into baseband using only one optical demodulator at the receiver. The performance of the system was evaluated for 10 Gb/s using

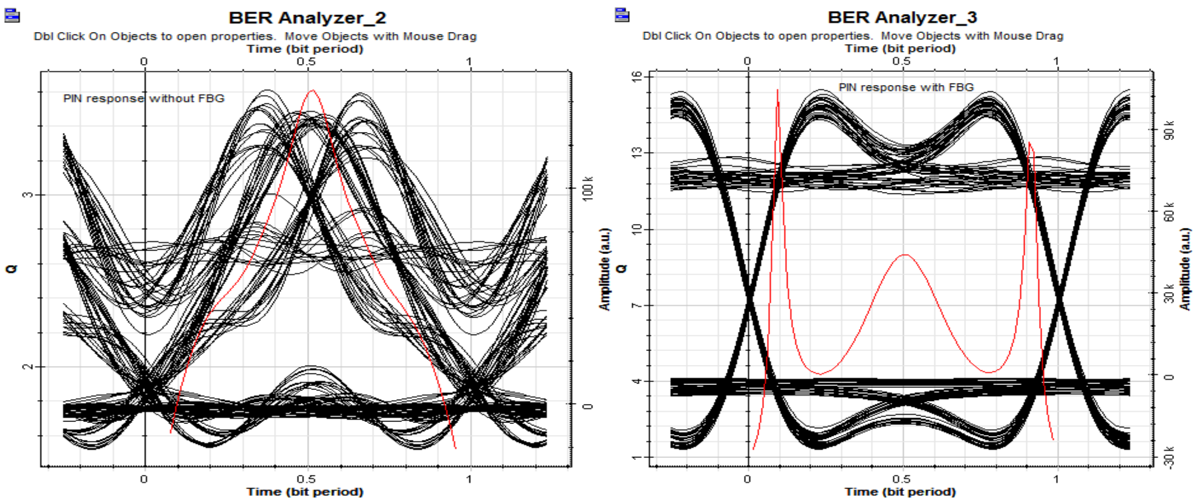

Figure 4. (a) PIN Response before FBG over 50 Km; (b) PIN response after FBG over 50 km.

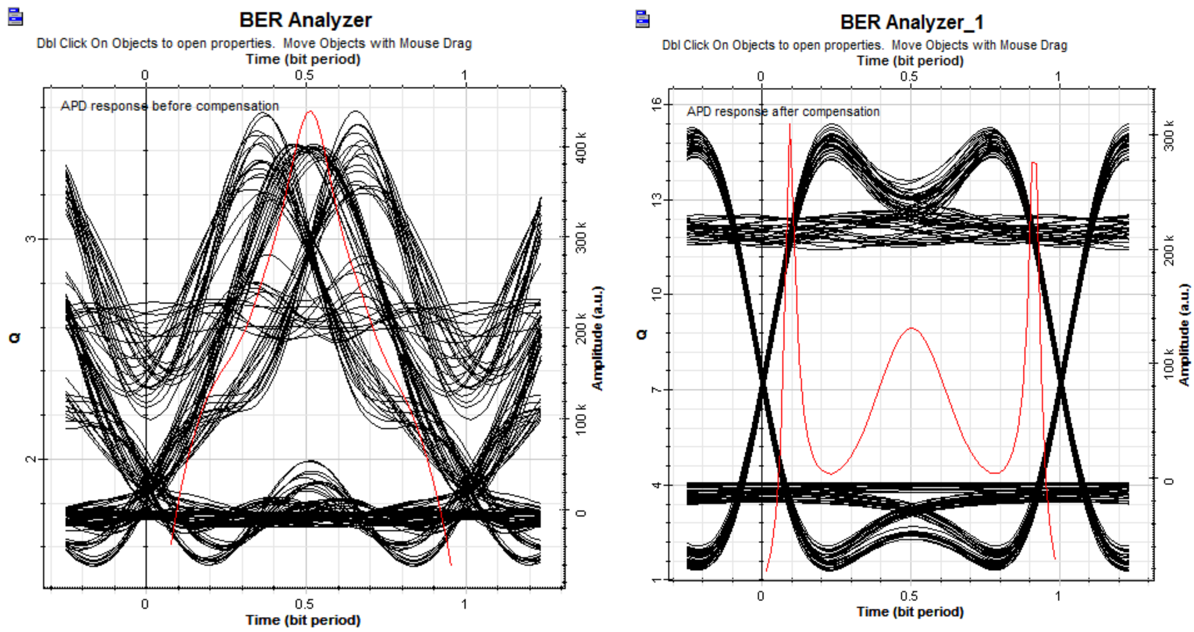

Figure 5. (a) APD Response before FBG over 50 Km; (b) APD response after FBG over 50 km.

Table 1. Numerical results APD as receiver.

	APD Receiver	
	Without FBG	With FBG
Q-Factor	3.58158159	15.3956
BER	0.000139952	8.7353e−054

Table 2. Numerical results PIN as receiver.

	PIN Receiver	
	Without FBG	With FBG
Q-Factor	3.61174	15.5166
BER	0.000124989	1.3385

Fiber Bragg Grating as a compensator of dispersion effect over 50 Km Universal Single Mode Fiber (SMF) of adapting Radio over Fiber System. The Q-factor of the system has been increased by 5 times when an Ultrafast Avalanche Photodiode (APD) is used at the receiver considerably compared to the system using Positive Intrinsic Negative (PIN) as at the receiver. Minimum BER also reduced significantly by using Fiber Bragg Grating, which is shown in **Table 1** and **Table 2**. However, there are still possibilities to extend the technology by discovering a different component for improving the system capacity in the near future.

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