MULTICHANNEL COST EFFECTIVE FULL DUPLEX RADIO OVER FIBER COMMUNICATION SYSTEM USING FIBER BRAGG GRATING FILTER

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ABSTRACT

The Radio Over Fiber (ROF) technology facilitates a reliable, efficient and cost effective transportation of radio frequency information signals of any protocol and application between any two stations. In this paper, cost effective full duplex two channel ROF transport systems based on BPSK modulation scheme , capable of delivering a data rate up to 1 Gbps , is proposed. The remodulation implemented utilizing Fiber Bragg Grating(FBG) filters greatly simplifies the base station installation and reduces the overall system cost. The bit error rate is analyzed and presented.

Keywords: Radio Over Fiber (ROF), Fiber Brag Grating (FBG), Erbium doped Fiber Amplifier (EDFA)

1. INTRODUCTION

The field of communication constantly demands for larger band width with cost effective technologies and implementation procedures. The wireless communication has occupied a major bulk of the communication arena with its inherent advantages. But of course it do face some limitations. Many technologies and protocols have been evolved in the wireless communication field. Further long distance communication requires repeaters and that the repeaters need to be well equipped with the respective technology. This is a major challenge in the wireless communication.

The advantages of optical fiber as a transmission medium with low loss, light weight, very large bandwidth characteristics, small size , immunity to electromagnetic interferences etc make it the ideal and most flexible solution for efficiently transporting radio signals to remotely located antenna sites in a wireless network. The Radio Over Fiber (ROF) technology modulates the RF modulated data signals on to optical carrier frequencies and transported over optical fibers. It can largely simplify the design of the communication network. The major advantage is that the communication equipments corresponding

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to the different channels and technology can be limited to the transmitting and receiving ends [1]. Many innovations have been proposed to improve the efficiency and cost effectiveness of the ROF system. Techniques to utilize the same wavelength for the uplink and downlink communication using Reflective Semiconductor Optical Amplifiers (RSOA) offered some solution [2]. The development of a Full duplex ROF system with FBG at the base stations was another achievement[3]. The proposal for a full duplex cost effective system utilizing frequency reuse for the uplink communication using FBG is another major advantage[4]. The proposed work in this paper utilizes the major innovations mentioned above and is mainly oriented to improve the number of channel and distance, with frequency reuse using FBG filters [4] for ROF transportation . Here a full duplex two channel ROF system utilizing the same optical carrier frequencies for the downlink and uplink communication is implemented using reflective FBG filter. The system is implemented in OptiSystem.

The paper is organized as follows: Section 2 describing the architecture of the proposed systems, section 3 analyzing the results , whereas the conclusion and future work is included in the section 4.

2. THE PROPOSED SYSTEM

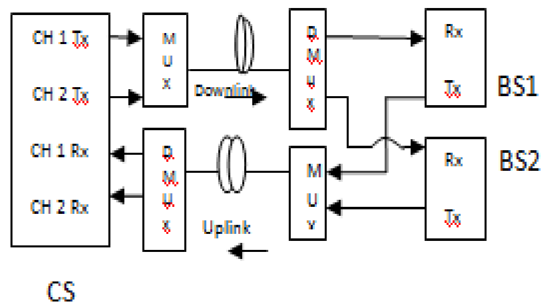


Fig.1. Simple Block Diagram

The concept of the proposed system can easily be understood with the simple block diagram illustrated in Figure 1.The proposed system is designed to effect full duplex communication between a central station CS and two base stations BS1 and BS2. The data at the channel 1(CH1) and channel 2(CH2) of the central station are modulated on two different optical carrier frequencies and are multiplexed to a single mode fiber to the base station side. At the side of the base stations, the two signals are de-multiplexed and fed to the respective base stations. The signal received at each base stations is split into two parts - one part is fed to the demodulating section to retrieve the data whereas the other part is fed to a reflective Fiber Bragg Grating (FBG) filter to retrieve the optical carrier frequency. The data from the base stations corresponding to the channel 1 and channel 2, are modulated on the respective recovered optical carriers and are multiplexed on to a single mode fiber to the central station . At the side of the central station , the signals are de-multiplexed and fed to the respective receivers to recover the data.

The feature of recovering the optical carrier at the base stations and reusing the same for uplink communication to the central station largely simplifies the design and implementation of the base stations, thus reducing the overall system cost[4]. The down link and uplink communication of channel 1 is effected with 193.1 THz signal while the channel 2 utilises 193.2 THz signal.

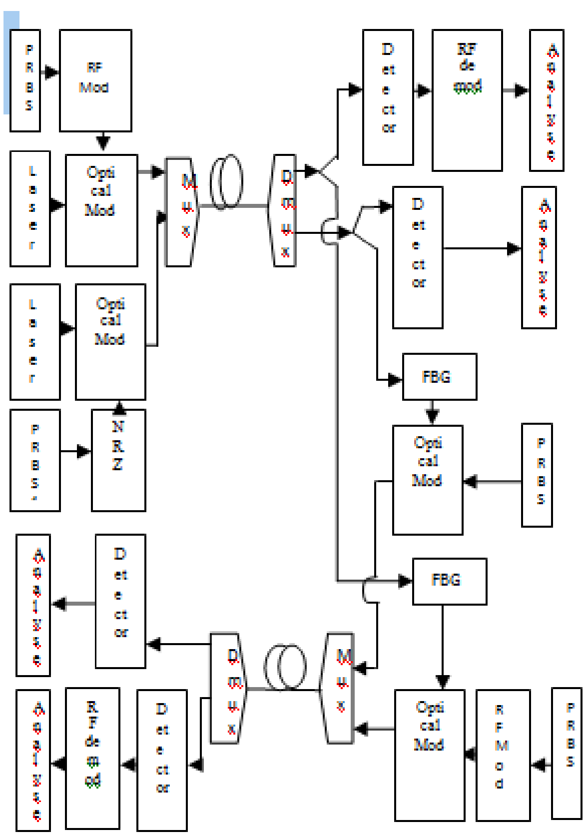


Fig. 2. Architecture of the proposed system

The Figure 2 illustrates the architecture of the proposed system. The functioning of the proposed system can best be explained in two sub sections as

(i) Downlink communication from the central station to the base stations

(ii) Uplink communication from the base stations to the central station

2.1. DOWN LINK COMMUNICATION FROM THE CS TO THE BS

At the Channel 1 of the CS, a Pseudo Random Bit Sequence (PRBS) generator generates a 1 Gbps base band data. The PRBS represents the various data sources. This base band data is then RF modulated with 5.825 GHz carrier signal. The binary phase shift keying (BPSK) modulation scheme have been implemented here . The RF modulated data is then filtered by a Gaussian band pass filter centered at 5.825 GHz and is then optically modulated by a Mach-Zehnder modulator on 193.1THz carrier signal from a continuous wave laser at 10 mW power. At channel 2, a 500 Mbps baseband data generated by a PRBS generator is filtered by a Gaussian band pass filter and is optically modulated by a Mach-Zehnder modulator on 193.2 THz carrier signal from a continuous wave laser at 1mW power.

The optically modulated signals from the two channels are multiplexed and fed to a single mode fiber(SMF) to be transported to the base stations. At the side of the base stations, a de-multiplexer feeds the two signals to the respective base stations. In the base station 1, the received signal is split into two parts. One part is fed to a PIN diode photo detector of responsivity 0.9 A/W to perform optical demodulation and yields the RF modulated signal. This is then filtered by a Gaussian BPF centered at 5.825 GHz and is fed to the BPSK demodulator to retrieve the baseband data. The recovered baseband data is fed to the BER analyzer for analysis. The other part of the received signal is used to retrieve the optical carrier frequency of 193.1THz by using a reflective FBG filter. This recovered optical carrier frequency will be used for the optical modulation of data from the base station 1, during the uplink communication in channel 1 to the central station.

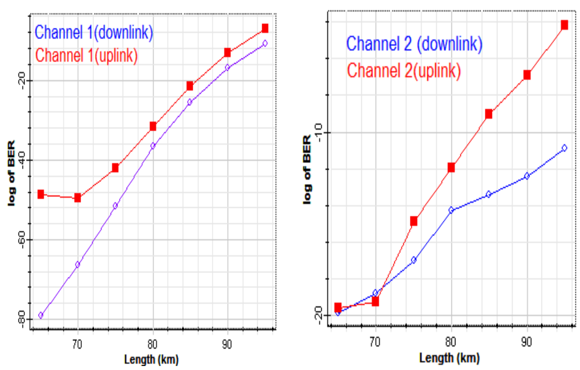
At the base station 2 also, the received signal is split into two parts. One part is fed to a PIN diode photo detector of responsivity 0.9 A/W to perform optical demodulation and is then filtered with a Gaussian BPF centered at 1 GHz to yield the base band data. This is then fed to the eye diagram analyzer for analysis. The other part of the received signal is used to retrieve the optical carrier frequency of 193.2THz by using a reflective FBG filter. This recovered optical carrier frequency will be used for the optical modulation of data from base station 2, during the uplink communication in channel 2 to the central station.

2.2. UPLINK COMMUNICATION FROM THE BS TO THE CS

The uplink Communication is done similar to the downlink communication. The base band signal of 1 GHz generated by the PRBS at BS 1 is RF modulated on 5.725 GHz signal and is then filtered by a Gaussian Filter centered at 5.725 GHz. Here also the BPSK modulation is implemented. The RF modulated signal is then optically modulated by a Mach-Zehnder Modulator on the recovered optical carrier of 193.1 THz. Similarly at the BS 2, the base band signal of 500 Mbps generated by the PRBS is modulated by a Mach-Zehnder Modulator on the recovered optical carrier of 193.2 THz. The two optically modulated signals are multiplexed on to a single mode Fiber to the central station. At the side of the CS, a de-multiplexer separates the two signals and are fed to the respective receivers of CH 1 and CH 2 for demodulation. An EDFA of length 2.8m used at the CS ensures better communication. The recovered base band data at the receivers are fed to the BER Analyser for analysis.

3. RESULT ANALYSIS

The performance of the system was analysed at different fiber lengths and was found to operate satisfactorily up to 100 Km. To analyse the system performance, sample graphs for the downlink and uplink communication of the two channels have been plotted for Seven different fiber lengths between 65 Km and 95 Km. The eye diagrams are also obtained for both the channels in the uplink and downlink.

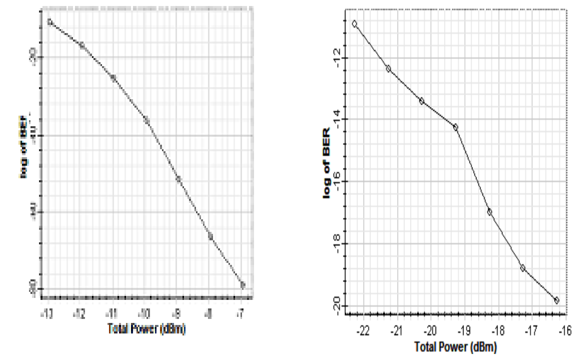


(a) (b)

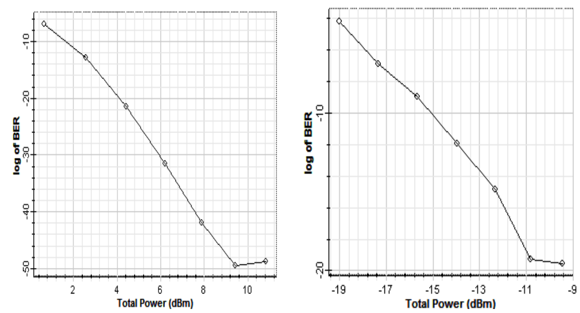
Fig.3. BER Vs Fiber Length.

(a) Channel 1 (b) Channel 2

Figure 3 shows the plot of the variation in BER with fiber length for the uplink and downlink communication of channel 1 and channel 2. BER is found to be in the acceptable level in all the cases. The BER was found to increase with fiber length, as in any communication. The down link BER of both the channels was lower than that of the uplink. The increase in BER of the uplink is caused by the lower power associated with the recovered optical carrier signals at the base stations.



(a) (b)



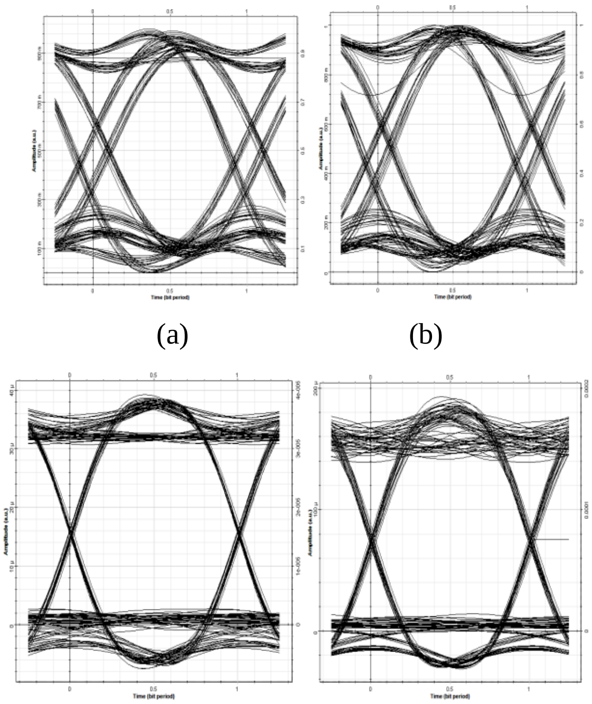
(c) (d)

Fig .4 BER Vs Optical Power

(a). CH1 Downlink (b). CH2 Downlink

(c). CH1 Uplink (d). CH2 Uplink

The variation in the BER with optical power of the two channels in the downlink and uplink communication is plotted in Fig 4. The BER was found to increase with decrease in the optical power which in fact is a function of the fiber length also.



(a) (b)

(c) (d)

Fig.5 Eye diagram (a) CH1 downlink (b) CH1 Uplink (c) CH2 Downlink (d) CH2 Uplink

Eye diagrams of enough height and width were obtained in the two channels for the downlink and uplink communication. The eye diagrams are plotted in Figure 5.

4 . CONCLUSION AND FUTURE WORK

A two channel full duplex ROF system based on BPSK modulation scheme has been simulated and is verified to operate well up to 100 Km. The optical carrier frequencies from the central station are retrieved at the base stations and are used for the uplink communication to the central station, thus simplifying the base station design and reducing the cost. Future works can be done to increase the number of channels, bit rate and with different modulation schemes.

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