SIMULATIVE ANALYSIS OF OPTICAL OFDM SYSTEM USING EDFA-RAMAN HYBRID OPTICAL AMPLIFIER

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ABSTRACT:

This paper demonstrates the architecture of direct detection optical Orthogonal frequency division multiplexing OFDM systems and carries out performance analysis based on EDFA-RAMAN hybrid optical amplifier in terms of bit error rate and Q-factor at different input powers. It is found that the signal can be transmitted with acceptable BER and Q-factor at low signal input power of -0.7 dBm upto 600 km transmission distance using EDFA-RAMAN hybrid optical amplifier. The signal can be transmitted successfully upto 512 km without hybrid amplifier at 10 Gbps bit rate.

Keywords: OFDM, BER, QAM, Q-factor, EDFA-RAMAN.

[1] INTRODUCTION

There is a growing demand for high speed, spectrally efficient and reliable communication. Providing high quality services in an optical environment has several challenges. Optical Orthogonal Frequency Division Multiplexing is considered as a promising technology to satisfy the increased demand for bandwidth in broadband services [1]. Orthogonal Frequency Division Multiplexing (OFDM) essentially identical to Coded OFDM (COFDM) is a digital multi-carrier modulation scheme, which uses a large number of closely spaced orthogonal sub-carriers [2]. OFDM splits the total transmission bandwidth into a number of orthogonal and non-overlapping subcarriers and transmit the collection of bits called symbols in parallel using these subcarriers. The main advantage of the OFDM is its ability to overcome channel dispersion. Also, OFDM has the ability to transmit information with high data rates which has made it popular [3]. OFDM has been used in many different applications in the RF domain such as digital audio broadcasting (DAB), digital video broadcasting (DVB), and Wireless Local Area Networking (WLAN) [4-5].

Hybrid amplification is an effective technique for optical regeneration; it has a low NF as compared to individual fiber amplifiers. The gain profile is also much flatter, so they are able to accommodate more channels [6]. Nir Sheffi and Dan Sadot [7] proposed an Optical orthogonal frequency division multiplexing with a novel direct modulation and coherent detection system at
34.3 Gb/s and 16 QAM. The proposed system achieves $10^{-3}$ BER with 10.5 Eb/N0, similar to a standard single carrier system. N.E. Jolley et al. [8] demonstrated the generation of the fastest ever DQPSK encoded OFDM signal at 10 Gbit/s. The signal was transmitted using a 1550 nm, low cost, directly modulated, optical transmitter over 1000m of multimode fibre with a bandwidth of less than 1GHz. Minimal degradation to the performance was observed due to the differential encoding scheme and the use of a cyclic prefix in the data. The measured performance shows an acceptable error rate. Kang Zhaoyuan Ji Wei [9] analyzed a bidirectional radio over fiber system based on coherent optical OFDM (CO-OFDM). In the downlink, the 60 GHz millimeter wave modulated by orthogonal frequency division multiplexing is generated by remote heterodyne detection. The simulation result indicates that the system has a good transmission performance at 40 km coverage span. The paper is structured as follows. Section 1 presents the Introduction. Section 2 shows the system architecture. Section 3 illustrates the results and discussions for optical OFDM system based on hybrid optical amplifier. Section 4 comprises the conclusion of work.

[2] SYSTEM ARCHITECTURE

The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously in parallel over a number of subcarriers. All the sub-carriers are carefully controlled in order to maintain the orthogonality condition between the carriers. Every sub-carrier OFDM systems is assigned the same data during transmission. As shown in Fig 2, a binary message in form of bits at the transmitter is generated which has a length divisible by the number of subcarriers.

![System setup](image)

Figure 1 System setup

The signal of each sub-carrier is first modulated. Each sub-carrier in OFDM system can adopt different modulation scheme such as BPSK, QPSK, 8PSK, 16QAM, 64QAM, etc. At the transmission block, both modulation and multiplexing are achieved digitally using an inverse fast Fourier transform (IFFT) at the OFDM modulator. The subcarrier frequencies are mathematically orthogonal over one OFDM symbol period. The input serial stream of data is then converted to parallel sets of data at the transmitter. This arrangement is necessary for using the Inverse FFT in order to convert the frequency domain data sets into sample data of the corresponding time domain.
representation. In OFDM, the IFFT is useful for OFDM system due to the fact that, the samples of a waveform are generated with orthogonal frequency components. Quadrature modulator is used to modulate the I and Q components separately and the RF to optical up-conversion is done using a CW laser and a MZM. The resulting modulated signal is then transmitted to the receiver through the optical fiber. The transmitted signal is amplified by EDFA-RAMAN hybrid optical amplifier. At the receiver, avalanche photodiode is use to convert the optical signal into electrical signal. The photodiode is tuned at the frequency at which the signal is transmitted. The original data is then recovered from the modulated signal through OFDM demodulation technique. The received signal pass through a low pass filter and the serial data stream is then converted to parallel followed by the FFT of the signal. A demodulator is then used to get back the original signal. BER analyzer is used as the measurement component. By taking the considerations of the unmodulated signal and the data at the receiving end, the quality factor, bit error rate and the received power is calculated.

[3] RESULTS & DISCUSSION

To analyze the performance of the system quality factor and bit error rate are examined in the presence and absence of hybrid EDFA-RAMAN optical amplifier. The Q factor vs. input transmission power at 500 km and 600 km transmission distance is as shown in Fig.2. It is evident that the quality of the received signal decreases with decreasing the input transmission power. The acceptable Q factor (6.2) is obtained at -0.7dBm signal input power up to 512 km transmission distance. It is observed that when transmission distance increases, the value of quality factor decreases. The quality factor (5.8) is achieved upto 600 km transmission distance which is not acceptable.

Figure 2: Q-Factor vs. Input transmission power without EDFA-RAMAN hybrid amplifier
Figure 3: BER vs. Input transmission power without EDFA-RAMAN hybrid amplifier

Figure 3 depicts the Bit error rate vs. input transmission power at 500 km and 600 km transmission distance. It is observed that bit error rate increases as the input transmission power decreases. The acceptable value of BER(5.31e-10) is obtained at 500 km transmission distance. When the transmission distance increases from 500 km to 600 km, then value of BER (3.21E-09) increases.

Figure 4: Q-Factor vs. Input transmission power with EDFA-RAMAN hybrid amplifier

The Q-Factor vs. input transmission power with EDFA-RAMAN hybrid optical amplifier is as shown in figure 4. It is analyzed that by using hybrid optical amplifier, the performance of the OFDM system is improved. The acceptable Q-factor (6.5) at low signal input power of -0.7 dBm up to 600 km transmission distance is achieved. At -0.1 signal input power, the value of quality factor (13.12) is achieved.
Figure 5: BER vs. Input transmission power with EDFA-RAMAN hybrid amplifier

In Figure 5, bit error rate vs. input transmission power using EDFA-RAMAN amplifier is plotted. It is observed that minimum BER is obtained which is $1 \times 10^{-9}$ at 600 km transmission distance.

Figure 6: Q-factor vs. Input transmission power with EDFA-RAMAN hybrid amplifier at 600 km transmission distance

Figure 6 Shows the Q-factor vs. input transmission power with EDFA-RAMAN hybrid optical amplifier at 600 km transmission distance. It is found that the signal can be transmitted with acceptable Q-factor at low signal input power of -0.7 dBm upto 600 km transmission distance using EDFA-RAMAN hybrid optical amplifier. The signal can be transmitted successfully upto 512 km without hybrid optical amplifier.
[4] CONCLUSION

The optical OFDM system has been investigated with the placement of the EDFA-RAMAN hybrid optical amplifier and the performance has been evaluated on the basis of BER measurement and Q factor. It is analyzed that by using EDFA-RAMAN hybrid optical amplifier, the performance of the OFDM system is improved and long distance is covered. Orthogonal frequency division multiplexing is an effective modulation format that has recently received much attention for use in fiber optic transmission systems because it has high spectrum efficiency, maintaining system robustness against fiber chromatic dispersion and polarization mode dispersion.

REFERENCES