ELIMINATING DISPERSION AND ISI IN OPTICAL WIRELESS ENVIRONMENT USING OPTICAL DFT OFDM SYSTEM

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Introduction

All optical orthogonal frequency division multiplexing (OFDM) is used to achieve high bit rate and eliminate intersymbol interference in optical wireless communications. Overall architecture is enlightened and analytical evaluation is presented for direct and diffused environment.

All Optical OFDM System

The push for higher data rates in wireless communications such as wireless multimedia applications has motivated recent interest in indoor wireless optical communications as the medium for short-range wireless communications [1]. The use of modulated light as a carrier instead of radio waves offers high potential. Directed link design maximizes power efficiency, since it minimizes path loss and multipath distortion. On the other hand, non-directed links increase link robustness and ease of use, allowing the link to operate even with barriers. However, the non-directed optical communications, which is referred to as a diffuse link, increases multipath distortion that causes intersymbol interference (ISI) problems. To combat the ISI effect, optical OFDM technique is one of the possible solutions [2].

All optical OFDM system that we are proposing differs from the conventional OFDM system in the conversion of the parallel low data rate substreams into optical signals and performing the inverse fast Fourier transform (IFFT) technique optically rather than electrically. Performing OFDM optically allows broadband data rate which cannot be reached using electrical OFDM as it is beyond the digital signal processing speed capabilities. The proposed system, shown in Fig. 1, consists of a serial to parallel (S/P) block, followed by modulating each optical substream using any type of an optical modulation as discussed in [3] having the same optical wavelength. The output goes into an optical IDFT [4] that consists of variable phase shifters and couplers. The phase shifters implement the different subcarriers that are orthogonal and thus will be similar to IFFT done by DSP kits as shown in the relation.

$$s(t) = \sum_{n=0}^{N-1} d_n(t) e^{j2\pi(f_o + n\Delta f)t}, \qquad \textbf{(1)}$$

where s(t) represents the multiplexed signals, n and $d_n(t)$ denote the channel number and the data sequence of the n^{th} channel, respectively. In (1), t = K Δt, where $\Delta t = (T/N)$ is the sampling interval, f_o is the frequency of the light source and Δf is the frequency spacing. A cyclic prefix (CP) should be added to overcome the ISI and intercarrier interference (ICI). This is performed by two fiber branches. The first is a fiber delay line and the second is an optical switch. The optical switch is used to copy the last guard time of the active ray period and couple it to the front of the optical ray by an optical coupler after it is delayed by the symbol period. At the receiver side, optical OFDM signal is detected by an optical receiver and then the optical cyclic prefix is removed. The IDFT and optical demodulator are performed to get the corresponding transmitted bit streams.

The probability of error, P_e, of a diffuse channel can be derived using a shifted lognormal probability density function by using Gauss-Hermite quadrature formula [4 and 5]. Figure 2 shows the P_e versus the electrical SNR at variance of 0.3 and at different Gauss-Hermit polynomial orders, n. This is repeated by using Gauss-Laguerre formula for LOS reflection paths channel is derived using a modified Rayleigh distribution, Fig. 3. In Fig. 3, $P_e = 10^{-5}$ at SNR = 10 dB while in Fig. 2, at the same SNR, $P_e = 0.1$ for diffused environments which is unacceptable. The comparison is logic because LOS link is free from the non-LOS disadvantage such as multipath fading that causes ISI.

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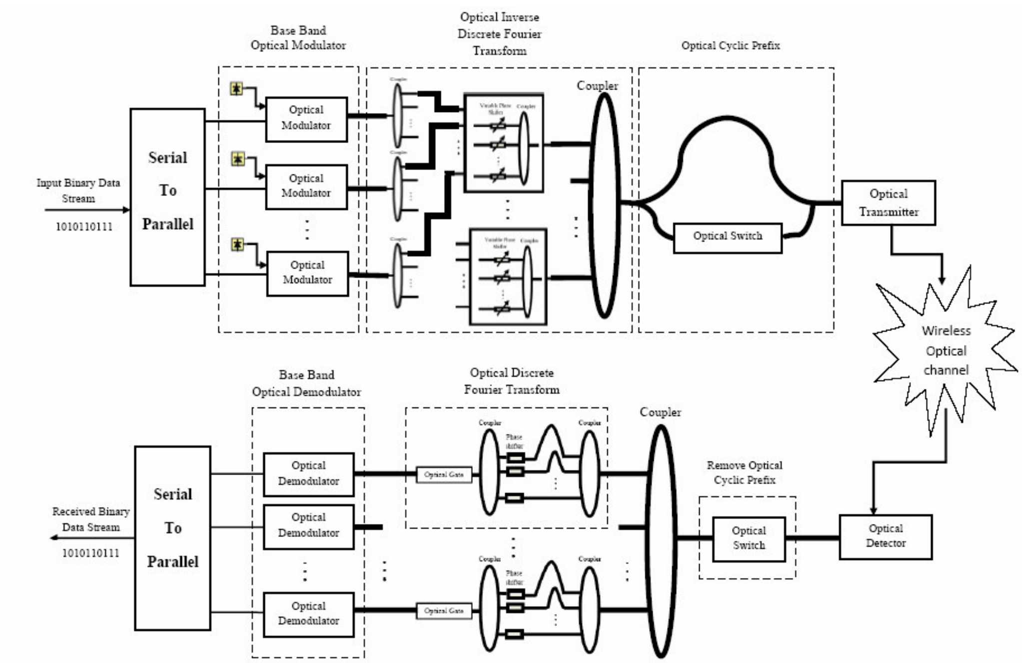

Figure 1.Complete System architecture of all optical OFDM

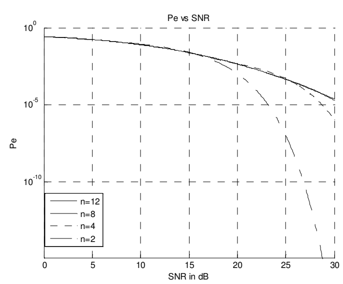

Figure 2.Probability of error in diffused channel

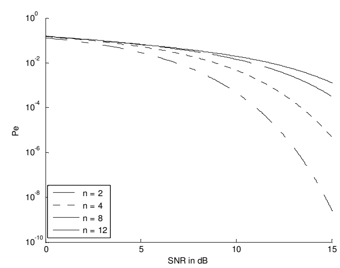

Figure 3.Probability of error in LOS channel

Conclusion

In this paper, a novel optical OFDM technique is proposed. The theory of system is explained along with the calculations of the probability of error in LOS and in diffused wireless optical communications

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