Gaussian Approximation of the BER for Non-Coherent Optical Fiber CDMA Networks Using Sparse Codes

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Abstract

An analysis based on a Gaussian approximation of the BER performance for non-coherent optical fiber code-division multiple-access (CDMA) networks (both asynchronous and synchronous) is presented. The effects of shot noise, thermal noise, interference and the architecture of optical receivers are included in the evaluation of the BER. A general equation for the BER is established and it is shown that using this equation, the results for special cases previously published by others were confirmed. BER performance for asynchronous optical CDMA systems using prime sequence codes and that of synchronous systems using modified prime codes were calculated. The author shows that the synchronous system can achieve better performance.

Keywords*: Optical communications, code-division multiple-access (CDMA), BER performances, Gaussian approximation, sparse codes, symmetric and non-symmetric codes, synchronus and asynchronus systems, optical orthogonal codes, temporal codes.*

Introduction

In recent years, there has been increasing interest in the design and analysis of non-coherent optical fiber code-division multiple-access (CDMA) systems. Depending on the requirement of time synchronization, there are asynchronous or synchronous systems (Kwong *et al.* 1991). In those systems, because the correlation is based on power summation, it is usually believed that conventional bipolar codes cannot be used, and therefore, new unipolar codes, which have only a small number of chips "1" were designed. Those codes are referred to as sparse codes (Parham 1992). In general, a sparse code is a family of (0,1) sequences characterized by a quadruple $(N,W,\lambda_a, \lambda_c)$ where N is the code length, W denotes the code weight (i.e. the number of "1" chips in a code sequence), and λ_a and λ_c are the maximum value of the out-of-phase auto-correlation (i.e., the auto-correlation for any shift other than the zero shift) and the maximum value of the periodic cross-correlation, respectively.

In a non-coherent optical fiber CDMA network using sparse codes each user is assigned a code sequence which serves as its address (or reference code sequence). This code sequence is approximately orthogonal (i.e., has low cross-correlation) with the code sequences of other users. When the receiver-based code is employed, the source user encodes each "1" bit to be transmitted with the code sequence assigned to the destination user and nothing is transmitted for "0" bits. At the receiver, the incoming signal is correlated with the receiver's reference code sequence for detecting the data bits. Although the receiver receives all of the energy sent by all of the transmitters, after despreading it will see only the desired signal. Provided that the code sequences used at any one time do not interfere with each other beyond a predetermined limit (i.e., their cross-correlation functions are below a given threshold) then a number of users may simultaneously access the network.

In recent years, several new sparse codes have been proposed. We can group those codes into two classes: non-symmetric codes and