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RESEARCH ARTICLE

OPTICAL CDMA USING L-PARALLEL CODES.

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Abstract

Fiber optic code-division multiple access (FO-CDMA) has expanded in last decade. This multiplexing scheme uses pseudo-random codes and spread spectrum with a wide frequency range. Every user is provided by specific code words, which subset of optical orthogonal codes (OOC). Here we discuss the Matlab implementation of L-Parallel code scheme to improve the performance of the system. Moreover this paper analyses the performance of FO-CDMA system, multiple access interference and its effect on error probability. Potential applications offered by this technology have been discussed in last.

Introduction:-

Well known fiber optic code-division multiple access (FO-CDMA) is one of the advance technique that allows several users to transmit data on a single channel simultaneously and hence provides high speed. It offers several advantages e.g. virtually infinite user capacity, potential of information security, decentralised network control, etc. Besides high speed as compared to electronic signal processing, it gives solution for efficient asynchronous multiple access networks. System performance may be increased by assigning proper signature codes, choice of appropriate detection schemes and proper signature codes, developing and using adequate error correcting codes, multidimensional FO-CDMA techniques and finally use of MAI cancellation and dispersion compensation technique. MAI appears due to the non-zero cross-correlation between the codes. Many techniques to overcome MAI have been reported by the researchers in past (1). The transmission distance is mainly limited by the MAI, since one user data becomes noise for all other users of the same channel. Therefore efficiency of the system is degraded (2).A set of codes that are suitable for FO-CDMA are optical orthogonal codes (OOC). These have the desired property that it should be easy to extract data with the desired code word in the presence of other user code words.

The purpose of this paper is to create a model for the L parallel scheme (discussed latter in this paper) and investigate the effect of MAI on the probability of error. The model has been implemented in Matlab because of its easy handling with vectors and matrices. For the encoding and decoding process each of the five L parallel codes have been implemented in a Matlab function.

Here we have neglected all physical noise (such as shot, thermal and beat noise) and focus is only on the crosstalk between users, i.e. MAI. This is an approximation because the inclusion of physical noise may have effect on the system performance. However the purpose of this work is to investigate the performance of the FO-CDMA system with respect to MAI.

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Optical Orthogonal Code

we know that in optical CDMA use of on-off keying produces the spreading binary codes, i.e. string of symbols of (0,1). These spreading codes are known as optical orthogonal codes (3,4).

Constrution of L parallel code:

Construction of ordinary parallel code is known, in which every user is given a number of code words which are part of set C which are part of larger set Cj.

In ordinary parallel code construction, signature codes are directly send without verifying weather information bit being 0 or 1 but in the L parallel code mapping of information bits onto the code word are totally different in order to gain higher rates. L parallel codes also use delay between code words to be sent to represent information. When a code is detected by the decoder, it can calculate the delay between code word and other received code words which are used by the same user. By using this information we can recover the encoded data so for this we need to know how to introduce delay in to the code word.

Types of L-parallel codes that are constructed for transmission purpose are listed below:
1. L-parallel code without synchronization (L-PCWS).
2. L-parallel code with varying synchronization (L-PCVS).
3. L-parallel code with fixed synchronization element (L-PCFS).
4. L-parallel code with error detecting property (L-PCE).
5. L-parallel code with error correcting property (L-PCEC)

For these five types of parallel code the following parameters are needed to be defined.
1. Encoding L-parallel code.
2. Decoding L-parallel code.
3. Cardinality and Rate of L-parallel code.

L-PCWS is the construction that gives the highest rate but the senders and receivers must be synchronized for this to work. L-PCVS gives a slightly lower rate but here a synchronization element is sent so there is no need for the system to be synchronized. For fixed synchronization element as for L-PCFS, the decoding process becomes simplified at the expense of lower rate. L-PCE also uses a fixed synchronization element and can also detect errors and can correct to some extension, to the expense of lower rate. L-PCEC can detect errors in the same way as L-PCE and is able to correct errors in the decoding process. Every detected code word now can be confirmed as an information carrier and not interference.

Matlab implementation:

Implemented Encoders

The encoders for the different L parallel codes are implemented in five Matlab functions. They are all block encoders, which means that the output is a vector of length 2n + L or 3n + L + S depending on the chosen code construction. The input parameters are:
1. C , which is the code matrix with code words as rows.
2. L is the chosen value of delay parameter L.
3. K ,the number of code words that will be used when encoding data
4. data is the information that will be encoded.

The length is one block length that depends on L and K and the choice of code construction.

A description of the encoders implementation has been given below.

L−PCWS.m: With definition L-PCWS it encodes the binary vector data of length Klog2(L + 2). If it is not of right length an error message is shown.
L−PCVS.m: Encodes the vector data of length log2(K)+(K−1)log2(L+1) with L-PCVS.
L−PCFS.m: Encodes data of length (K −1) log2(L+2) with L-PCFS.
L−PCE.m: Encodes a vector of length (K − 1)log2(L + 1) with L-PCE.
L−PCEC.m: Encodes a vector of length (K −1)log2(L+1) with L-PCEC.

Implemented Decoders

The presence of interference (MAI) due to other users, the code word may be repeated within L positions and decoder has to choose. The decoder chooses the first found code word moreover when multiple detection within L positions occurs the counter increases. Thus counter keeps the track number of times the multiple detections appeared and decoder has to make a choice.

In the decoding process the encoded vector is looped for every user once at a time. For the block decoder decode_L_PCWS.m user starts decoding at position (i) and decodes every block of length 2n+L. Recovered data is stored in .mat file. All other decoders decode_L_PCVS.m, decode_L_PCFS.m, decode_L_PCE.m and decode_L_PCEC.m take the entire coded vector as input, decodes it and returns the recovered data.

Result & Applications:-

Different parameters that affect the FO-CDMA system performance are non-linear effects, code design, dispersion MAI etc. MAI remains one of the serious problems to limit the number of simultaneous users (5,6,7). By simulating the L-parallel code, we analyse that use of this technology may reduce the MAI (multiple access interference) to a larger extend.

Optical orthogonal codes mainly find application in mobile communication, mobile radio, spread spectrum communication, radar and sonar signal design. Rapidly growing demand for commercial and military applications for underwater communications requires a reliable and practical multi-access network (8, 9). Due to limited speed and bandwidth of acoustic systems, wireless optical communication is preferred. It offers higher bandwidth, higher security and time latency. OCDMA is the most promising among many multiple access schemes. Further work is going on cellular underwater wireless optical CDMA Network.

Conclusion:-

In this paper we have discussed the fiber optic communication along with optical orthogonal code set. We defined the set of rules for OOC i.e co-relation properties. We have introduced L-parallel code scheme, which is a new way of mapping the information. In this paper, the physical noise: such as thermal noise, shot noise is ignored and there is no forward error correction method at the receiver end. These two points can be considered to be future scope of work in this technology.

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