Implementation of Unipolar Cyclic Shifted Walsh (CSW) Code in Optical CDMA System

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Abstract- In Optical Code Division Multiple Access (OCDMA), Spectral Amplitude Codes (SAC) is used widely to eliminate some of the dominant noise such as Multi user Interference (MUI).This paper proposed a simulation model for optical code division multiple access system based on Walsh code. The proposed paper realized a case study of three users and shows the construction of unipolar Cyclic Shifted Walsh code (CSW) with respect to beat noise, phase incoherent intensity noise(PIIN) and thermal noise. We also compare the performance of the proposed unipolar Cyclic Shifted Walsh(CSW)with the existing codes such as: Modified Frequency Hopping (MFH) code, Hadamard (HD) code and Modified Quadratic Congruence (MQC) Code.

Keywords- Optical Code Division Multiple Access (Optical -CDMA), Cyclic shifted walsh Code (CSW), Signal-Noise Ratio (SNR) , Bit Error Rate (BER).

I. INTRODUCTION

Code Division Multiple Access (CDMA) remains one of the most powerful communication tool for achieving optimization in wireless systems.the demand for single mode optical fiberhas increases due to its low losses and support higher bandwidth. Optical communication based cdma provides a large capacity, high security and better anti-interference ability. There will be no need for timing synchronization, wavelength control due to its high tolerance of noises [2]. Optical -CDMA technique is a prime solution for optical network since it could permit of many users to access the network asynchronously, simultaneously and provides flexible and secure transmission.

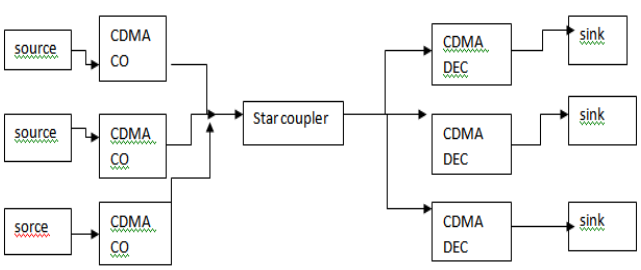

Fig .1: A basic block diagram of OCDMASystem

This paper is organized as follows. Section 2: develops an actual Unipolar Cyclic Shifted Walsh code (CSW) with zero in-phase cross correlation (λ). Section 3: presents the construction and performance analysis of CSW. Section 4: introduces the construction of other existing different architecture schemes codes. Section 5 introduces the appropriate results and section 6 conclusions of interest.

II. CODE CONSTRUCTION

The basic OCDMA has the following performance indices (N, w, λ), where N is the code length, w is weight of the code and λ is the in-phase cross-correlation (IPCC) [4] which is represented by:

$$\lambda = \sum_{i=1}^{n} x_i y_i \quad \text{-----------------(1)}$$

Eq.(1) shows the IPCC of two different code sequence for X(x1,x2,…..xn) and y(y1,y2,.….yn).

A basic2x2walsh code and 4x4 walsh code is written as [3]:

$$W_{2u} = \begin{matrix} 1 & 1 \\ 1 & 0 \end{matrix} \quad \text{and} \quad W4u = \begin{matrix} W2 & W2 \\ W2 & \overline{W2} \end{matrix}$$

$$\text{And} \quad \overline{W4u} = \begin{matrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{matrix}$$

To design the cyclic shifted unipolar Walsh code, we follow the below stated steps:-

StepI: Firstly consider the three basic rows R1=[101], R2=[110], R3=[011] by discarding first row & first coloumn.

STEPII: New set of code, S1 is generated by cyclic shift as given below

S1=

K×N=3×9	Coloumn1-2-3	Coloumn4-5-6	Coloumn7-8-9
Row1	R1	R2	R3
Row2	R2	R3	R1
Row3	R3	R1	R2

S1=

K×N=3×9	Coloumn1-2-3	Coloumn4-5-6	Coloumn7-8-9
Row1	101	110	011
Row2	110	011	101
Row3	011	101	110

We represent this code set as K×N,where K is the no. of user and N length of code.
Similarly S2 can be generated by simply

$$S2=\begin{matrix} S1 & O \\ O & S1 \end{matrix}$$

Where O= is a matrix containing all 0 elements.

The same procedure can be repeated to get the code for higher no. of users.
. The code properties can be represent by

$$\sum_{i=1}^{N} c_k(i)c_j(i) = \{w, when k = j \text{ and 0 otherwise}\}$$
---------(2)

Where ck denote the code sequence of kth row of K x N unipolar cyclic shifted Walsh code matrix, **Ck(i)= kth row of** unipolar cyclic shifted Walsh code matrix and K= number of active users.This designed CSW code has weight(W)is always constant and always equal to 6 and N is always three times of no. of user K.
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III. PERFORMANCE ANALYSIS:

3.1. The Signal to noise Ratio (SNR) and Bit Error Rate (BER) analysis of CSW code:

In case of an OCDMA code W and X are the two most important parameters as they directly affect the overall system signal-to-noise ratio (SNR).In this analysis we send a spectrally encoded pulse for data bit is 1 and no pulsefor data bit 0. Also we have considered incoherent intensity noise, as well as shot and thermal noises. The effect of the receiver's dark current is neglected. Gaussian approximation is used for the calculation of BER. For the detection of light from thermal source, the variance of photocurrent can be expressed as [2]

$$\langle i^2 \rangle = 2eIB + I^2 B\tau_c + \frac{4KTB}{R_L}$$
----------(3)

Where,
e= charge on electron;
I=avg. photocurrent;
B=noise-equivalent electrical bandwidth of the receiver;
τ_{c}=incoherence time of source;
K=Boltzmann's constant;
T=absolute receiver noise temperature;
R=receiver load resistor;
we may neglect dark current and thermal noise at the time of the mixing of two uncorrelated identically polarized light fields. Therefore phase induced intensity noise (PIIN) produces the photocurrent variance is

$$\langle i^2 \rangle = I^2 \tau_c B \quad \text{where the source coherence time} \quad \tau_c = \frac{\int_0^{\alpha} G^2(v)dv}{[\int_0^{\alpha} G(v)dv]^2}$$

We made the following assumptions:-

i) Each user has same power at the receiver.
ii) The cross correlation is ideal and λ equal to zero.
iii) Each bit stream from each user is synchronized.
iv) Each power spectral component has identical spectral width.

Based on the above assumptions, we can easily analyze the system performance using Gaussian approximation. The PSD of the received optical signals can be written as[2]

$$r(v) = \frac{Psr}{\Delta v}\sum_{k=1}^{K} d_k \sum_{i=1}^{N} c_k(i)c_l(i)\left\{u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i-2)\right] - u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i)\right]\right\}$$

--------- (4)

The power spectral density is G(v)at the photo diode. Therefore the incident power in the photodiode at the receiver end is given by

$$\int_0^{\alpha} G(v)dv = \int_0^{\alpha}\left[\frac{P_{sr}}{\Delta v}\sum_{k=1}^{K} d_k \sum_{i=1}^{N} c_k(i)C_l(i)\left\{u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i-2)\right] - u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i)\right]\right\}\right]dv$$

$$\sum_{k=1}^{K} d_k = K$$

$$u(v) = 0 \to v \lhd 0$$

$$u(v) - 1 \to v \geq 0$$

$$u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i-2)\right] - u\left[v - v_0 - \frac{\Delta v}{2N}(-N+2i)\right] = u\frac{\Delta v}{N}$$

$$I = R\int_0^{\alpha} G(v)dv = \frac{P_{sr}}{N}WK$$

--------------(5)

Therefore by using formula (5) the expression of SNR can be written as[2]

$$SNR = \frac{3\Delta v}{BK}$$

--------------(6)

IV. OTHERS CODE CONSTRUCTION

A. Modified Quadratic Congruence Code(MQC):

The HD code with weight (w) = P+1 & Cross-correlation(λ)= 1 supports the max. no. of user (K)= P^2. The formula for SNR estimation as follows:

$SNR_{MQC} = \frac{2p\Delta v}{BK(\frac{K}{2}+p-1)}$

B. Multi Frequency Hopping(MFH)

The HD code with weight (w) = q+1& Cross- correlation(λ)= 1 supports the max. no. of user (K)= q^2. The formula for SNR estimation as follows:

$SNR_{MFH} = \frac{2q\Delta v}{BK(\frac{K}{2}+q-1)}$

C. Hadamard code(HD)

The HDcode with weight (w) $=2^{M-1}$& Cross- correlation(λ)= 2^{M-2} supports the max. no. of user (K)= 2^M-1. The formula for SNR estimation as follows:

SNR(HD) = $\frac{4\Delta v}{BK2}$

TABLE-1

codes	No. of user[K]	SNR
CSW	$\frac{N}{3}$	SNR=$\frac{3\Delta v}{BK}$
HD	2^M-1 --------------(7)	SNR(HD)=$\frac{4\Delta\square}{\square\square 2}$
MFH	q^2	SNR=$\frac{2\square\Delta\square}{\square\square(\frac{\square}{2}+\square-1)}$
MQC	P^2	SNR=$\frac{2\square\Delta\square}{\square\square(\frac{\square}{2}+\square-1)}$

--------------(8)

TABLE-2

SinglesourcePoweratReceiver	Psr=10mW
Photodetectorquantumefficiency	η=0.8
linewidthofthethermalsource	ΔV=3.5THz
Operatingwavelength	λ=1.31μm
Electricalbandwidth	B=131MhZ
Receivernoisetemperature	T=300K
Receiverloadresistor	RL =1K

-------------(9)

V. SIMULATION ANALYSIS

The BER has been calculated by using the following equation:

BER = $0.5\mathrm{erfc}\sqrt{SNR/8}$ (10)

Taking the parameters of Table 2, SNR and BER are calculated using equation 6,7,8,9 and 10 respectively for unipolar cyclic shifted Walsh code.

Table 3.the result of BER for different architecture schemes.

codes	BER for Selected Architecture
CSW	1.1e-10
HD	0.3576
MFH	0.301
MQC	0.0209

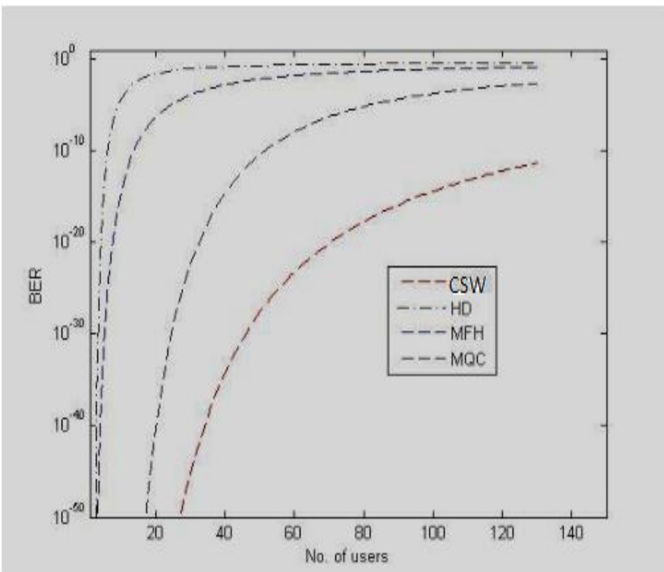

Fig.2: BER for different OCDMA

Figure 2 depicts the relation between the number of users and the BER for MFH[5],MQC[2] and HD code[5] where they have been plotted for different values of K (number of users).The above figure clearly shows that CSW code results much better .

VI. CONCLUSION

In this paper a new code (CSW) has been designed which shows a better performance compare to other existing codes. To conclude the advantages of the designed code can be summarized as 1) Based on calculation SNR, BER of OCDMA system using CSW are better, 2) The system simulation also shows lower value of BER, 3)The code weight is fixed which implies a simple architecture.

VII. REFERNCES

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