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Keywords : DOCDMA, BER, TOF, MAI, PIIN.

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PERFORMANCE ANALYSIS OF DYNAMIC OCDMA USING MATLAB

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Performance Analysis of Dynamic OCDMA using Matlab

Shweta Patel [α], Prof. Mukesh Tiwari [σ] & Prof. Jaikaran Singh [ρ]

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I. Introduction

Numerous optical CDMA communication systems have been proposed in the last two eras. Attractive incoherent systems are, among others, spectral amplitude coding (SAC), direct sequence (DS), and fast frequency hopping (FFH) optical CDMA systems. DS optical CDMA system encodes the incoherent pulses in time domain and recovers the data at the receiver using taped delay lines. The performance of this system is pitiable because of the correlation properties of the unipolar codes used, which contributes to a high level of multiple access interference (MAI). SAC scheme is a more recent technique in optical CDMA systems where the spectrum of a broadband source is amplitude-encoded. In both systems, MAI can be canceled by balanced detection and code sequences with fixed in-phase cross correlation. However, its performance is still narrow by phase induced intensity noise (PIIN). This limits the maximum number of users in the system. Furthermore, the spatial distance between the gratings and the number of gratings limits the users data bit rate in the system. Moreover, all the above systems are either non-reconfigurable, or they need complicated reconfigurable encoders. In this paper we propose an easily reconfigurable optical CDMA (OCDMA) system. The encoder varies the central frequency of a pulse of optical signal according to the functional code set to the controller. The system can recover the encoded data by matched decoders at the receiver. In OCDMA, the TOF should be able to follow the functional code given as an electrical signal by the controller during one bit interval. The small data bit interval of the high data bit rate system requires fast TOF or special code with tuning range suitable with the speed of the TOF. However, tunable optical filters which can scan 10's of Nano-meters within few nanoseconds have been reported. Thus, the encoder and decoder can be easily and quickly reconfigured to any of the functional codes. The implementation of the system leads to better performance of the network. It is shown here that the system performance is better than that of SAC and FFH systems recently.

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II. System Configuration and Description

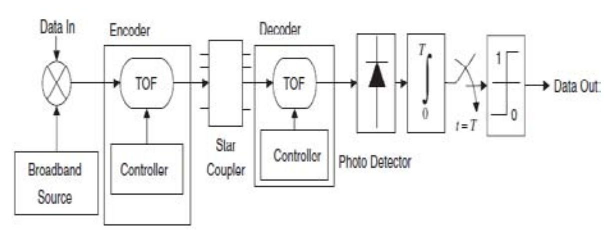

Fig. I (a) : Block diagram of dynamic OCDMA system

The block diagram in Fig. I(a) shows the dynamic OCDMA Configuration . The incoming signal from the light source (OOK) modulated with the binary data. If the data bit is "I", encoder will filters the spectrum of the pulse at a central wavelength varies with time according to a functional code, otherwise no power is transmitted. The encoder is a TOF controlled with an electrical signal that represents the functional code. Signals transmitted from all synchronized users will be joint using a star coupler before received by all users. At the receiver, the complex signal is decoded by a

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matched TOF. For recuperate the transmitted data, the signal passes through a photo detector, an integrator, and a threshold decision. The source spectra are assumed to be flat over the bandwidth of v0 with magnitude Pr/u, where u0 is the central optical frequency, Du the system bandwidth, and Pr the received effective average power from a single source. Some additional losses in the route of the signal and the receiver are supposed to be integrated in Pr. Ideal covering at the TOF is also assumed, and every operator is considered to have the similar effective average power at each receiver

III. Code Details

The core condition in the functional codes construction is toward reduce the number of intersecting points among any couple of functions then they increase the interfering power between users. The part of intersection among any two functions is associated directly to the cost of interfering power. The code family is given by

$$F^j(t)=\Delta/2(\sin(2\pi ft- j\varphi)) \quad (1)$$

Where K is the no. of simultaneous users, f is the φ frequency of functional codes and f is the phase shift between different functions. Shifted sine functions are offered for their ease and the possibility of completing the large number of required codes by decreasing the phase shift. The TOF in dynamic OCDMA should be capable to follow the functional code driving the filter. The required speed of the TOF and its controller is defined as the derivative of the code and given by

$$S^j(t)=\Delta v\pi f(\sin(2\pi ft-j\varphi)) \quad (2)$$

It is directly related to the frequency and amplitude of the functional code. Hence, other codes could be proposed to improve the system performance and operation of the system for high data bit rates. Also, the functional codes should start and stop at the same central wavelength in the data bit interval (T) for even modulation of the TOF and its controller. For these explanations, we use the smallest frequency probable for the SSC which matches to the data bit rate.

IV. Dynamic-Ocdma Performance Analysis

The PSD G(v, t) of the signal at the receiver's input is the sum of all active users transmitted signals.

$$G_m^i(v,t) = \frac{P_r}{\Delta_v}\sum_{j=1}^{K} b^j \text{ rect } \left(\frac{v-v_{0-F^j(t)}}{BW}\right) \quad (3)$$

where Pr is the effective power

The decoder output is given below

$$G_M^0(v,t) = \frac{P_r}{\Delta_v} b^m \text{ rect } \left(\frac{v-v_{0-F^m(t)}}{BW}\right) + \left(\frac{P_r}{\Delta_v}\right. \sum_{j=1,j\neq m}^{k} b^j\, rect\left(\left(\frac{v-v_{0-F^j(t)}}{BW}\right)\right) * \text{rect}\left(\frac{v-v_{0-F^m(t)}}{BW}\right) \quad (4)$$

After the integrator and sampler, the optical photocurrent is

$$I_m = 1/T \int_{T=0}^{T} I_m(t)dt = K b^m \frac{P^r}{\Delta_v} BW + K\frac{P^r}{T\Delta_v}\sum_{j=1,j\neq m}^{k} b^j * \sum_{i=1}^{N_{mj}} \left(BW(tH_i^{mj} - tL_i^{mj}) - \int_{tL^{mj}}^{tH_i^{mj}} |F^j(t) - F^m_i(t)|\, dt\right). \quad (5)$$

In the analysis of bit error rate (BER), we consider the effect of MAI, PIIN, and the thermal noise. Other sources, like shot noise and receiver's dark current noise, are neglected. Gaussian approximation is assumed for the distribution of the noise in the calculation of the BER.

Since the system is synchronized, users m and j will interfere at the same points in time relative to the beginning of the bit period and the intersecting edges (1Li m,j ,1Hi m,j) are the same whenever users m and j are active. This results in a constant value of DAI(m, j) if users m and j are active, otherwise DAI(m, j) is zero. For equi probable data, DAI(m, j) is a random variable with Average

$$\mu_{DAI} = \frac{1}{K^2-K}\sum_{m=1}^{k}\sum_{j=1,j\neq m}^{k} DAI(m,j) \quad (6)$$

And variance

$$\sigma^2_{DAI} = \frac{1}{K^2-K}\sum_{m=1}^{k}\sum_{j=1,j\neq m}^{K} (DAI(m,j) - \mu_{DAI})^2 \quad (7)$$

Since we do not know which user will be active at any given time, we average over all code pairs. The mean MAI can be approximated as 4DAI and the variance is (K-1) V2DAI.

Incoherent light sources mixed at the input of the photodetector will cause intensity noise in the output current(PIIN). The variance of the photocurrent due to this type of noise is

$$\sigma^2_{PIIN_m}(t) = I^2\, \tau_C(t)B \quad (8)$$

Then, the variance of PIIN is zero at no interference and at the points of interference, Averaging along the bit period and averaging over all users will get the PIIN

Variance equation as

$$\frac{}{\sigma^2_{PIIN}} = \frac{1}{K}\sum_{m=1}^{k}\frac{1}{T}\int_0^T BK^2\sum_{j=1,j\neq m}^{k}\left(\frac{P^r}{\Delta_v}b_m + \frac{P^r}{\Delta_v}b_j\right)^2 * (BW\, F^m(t) - F^j(t)|) + \left(\frac{P^r}{\Delta_v}b\right)^2 |F^m(t) - F^j(t)|) * (u(t - \tau L_i^{mj}) - u(t-\tau H_i^{mj}))\, dt. \quad (9)$$

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The Signal to Noise ratio is

$$\text{SNR(K)} = \frac{I^2}{(K-1)\sigma_{DAI}^2 + \sigma_{PIIN}^2 + \frac{4K_b T_N B}{R_t}} \qquad (10)$$

According to the Central Limit Theorem, we can consider that the pdf of the variables obeys the Gaussian Distribution.

The Probability of Error is

$$\text{BER(K)} = 1/2\text{erfc}(\text{SNR(K)}/2)$$

V. Simulation Tools

For this implementation MATLAB is very suitable tool. MATLAB (matrix laboratory) is a calculating environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi- domain simulation and Model-Based Design for dynamic and embedded systems.

In 2004, MATLAB had around one million users across industry and academia.[2] MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB is widely used in academic and research institutions as well as industrial enterprises.

VI. Simulation Results

The BER for Dyanmic-OCDMA using proposed sine functional code family and another two OCDMA systems, one is FFH and the other is SAC system using either Hadamard code, MQC code with p ¼ 13 [2], or modified frequency hopping (MFH) code with q ¼ 16 [3] are plotted in Fig. 2 for the sake of comparison. It shows the relation between the BER and the number of simultaneous active users when Pr=-10dBm. In our calculations, we take quantum efficiency 0.6, Spectral width 30 nm and filter bandwidth BW = 0:165 nm. In the simulation, the total numbers of users considered are 31* 31=961. The active no. of users considered is 100. The effective source power is fixed at 0.1* 10^{-4} watts (-20 dBm) & 0.1*10^{-5} watts.

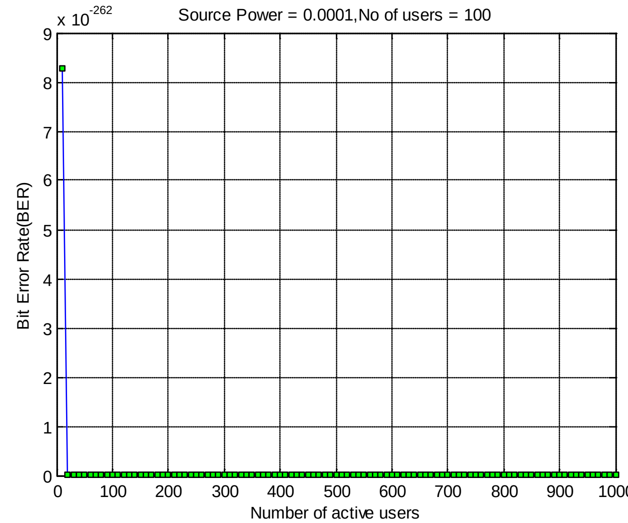

Fig. I : Comparison between BER & related users

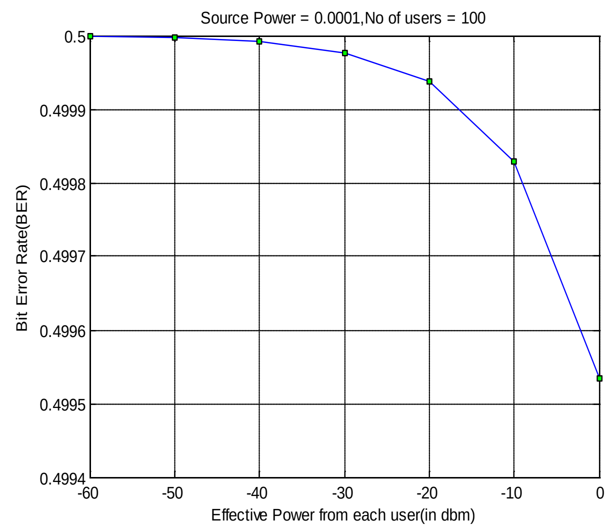

Fig. II : Comparison between BER & effective power

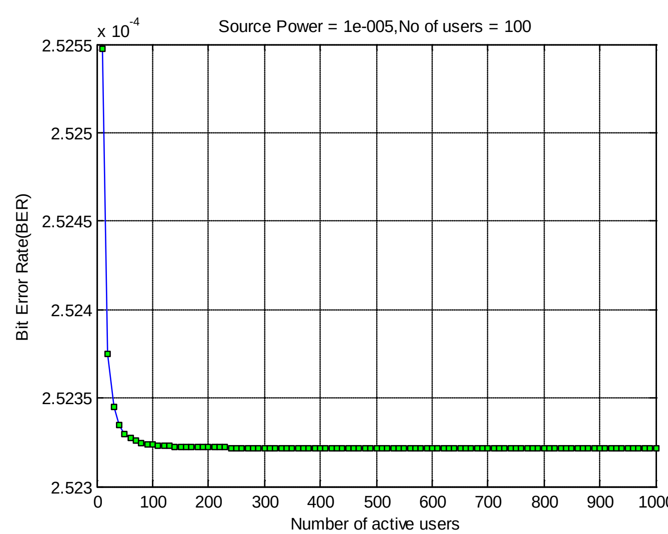

Fig. III : Comparison between BER & active users (100)

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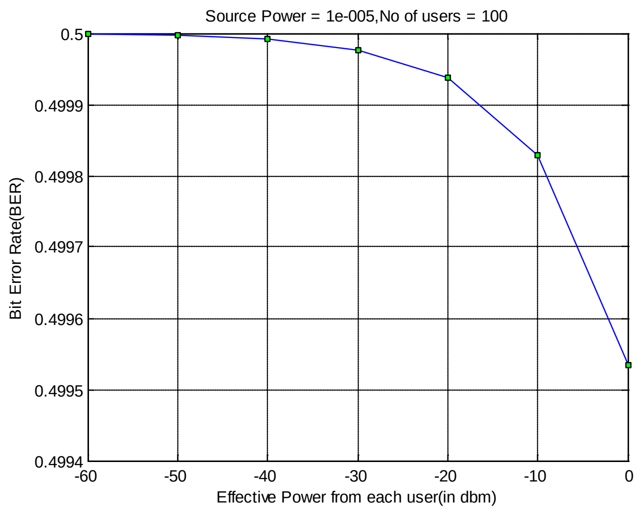

Fig. IV : Comparison between BER & Power from user

VII. Conclusion

We have planned a inventive low noise optical dynamic OCDMA communication system using a new two dimensional functional code. In transmitter side encoder used fast TOF & decoder design is based on fast TOF. The dynamically controlled of all filters and transfers one cycle through the data bit period. This encoder is simply reconfigured to some code by varying the electrical signal of the controller. The system is examined with a simple sine shifted functional code taking into account the MAI, the thermal noise, and the Phase Induced intensity Noise (PIIN).In these paper shows the comparison between BER with effective power from users & active users. In these system shows very small BER at large number of simultaneous active users compared with other systems like SAC and frequency hopping OCDMA systems. At 100 users, e.g., the system BER is improved. While in the dynamic OCDMA system, the data transmission rate is restricted by the tuneable filter's tuning speed, additional functional code relations can be used whereby the requirement for tuning speed can be reduced so that the system can support higher bit rates. The results show that the proposed DOCDMA system reduces the PIIN effect on the performance of the system and improves the bit error rate (BER) performance at a large number of users.

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