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To Enhancement a performance to differentiate between FCC (Flexible cross correlation) and DCS (Dynamic cyclic shift) code with there different parameters having AND subtraction detection technique of OCDMA using optiwave system design tool.

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Abstract :

Optical code division multiple access system (OCDMA) has been important with increasing demands of high capacity and speed for communication in optical networks. Due to OCDMA technique high efficiency is achieved, hence fiber bandwidth is fully used .In this paper we will focus on different codes i.e FCC (Flexible cross correlation),DCS (Dynamic cyclic shift) code with there different parameters i.e Optical fiber length, No of users, Weight, Receiver load resistor, Receiver noise temperature, Data bit rate, Operating Wavelength, Electrical bandwidth, Broadband effective power, Quantum efficiency of Detector using optiwave system design tool. Due to this codes we will eliminated MAI(multiple access interference) and improve BER (bit error rate) , PIIN(Phase induced intensity noise) and make orthogonality between users in the system .We will use AND subtraction detection technique to implement these codes with different parameters. In this paper, the study of different parameters is based on conference papers that is mainly demonstrated on an experiment to Enhancement a performance to differentiate between FCC (Flexible cross correlation) and DCS (Dynamic cyclic shift) code with there different parameters having AND subtraction detection technique of OCDMA using optiwave system design tool.

Index terms : OCDMA (optical CDMA) , BER (Bit error rate), MAI (Multiple access interference),FCC(Flexible cross correlation),DCS (Dynamic cyclic shift) , PIIN(Phase induced intensity noise).

1. INTRODUCTION:

Optical CDMA is providing each user asynchronous access to network without wavelength control. OCDMA system has been recognized as one of the most important technologies that many user can share media simultaneously and increase transmission capacity of an optical fiber.OCDMA has already been employed for LAN and for different network access application.

But OCDMA suffers from different noise such as shot noise , thermal noise, dark current and phase induced intensity noise (PIIN), Multiple access interference (MAI). Due to these many Codes are introduced such as FCC(Flexible cross correlation), DCS(Dynamic cyclic shift), MD(multi diagonal),KS, Modified Frequency Hopping (MFH), Modified Quadratic Congruence (MQC) and Modified Double Weight (MDW) codes. However, these codes have several limitations such as the code is either too long (e.g. Optical Orthogonal Code and Prime Code),construction is complicated (e.g. MFH code), or poorer cross correlation and fixed an even natural number for Modified Double Weight (MDW) code. But to avoide such interferences and make technology more efficient we will use these Codes . In these paper we will discuss about two codes i.e FCC and DCS with there different parameter such as Optical fiber length, No of users, Weight, Receiver load resistor, Receiver noise temperature, Data bit rate, Operating Wavelength, Electrical bandwidth, Broadband effective power, Quantum efficiency of Detector using optiwave system design tool. Due to this codes we will eliminated MAI(multiple access interference) and improve BER (bit error rate) , PIIN(Phase induced intensity noise) and make orthogonality between users in the system .We will use AND detection technique to implement these codes with different parameters.

In these paper there are 6 section : 1) Introduction 2) Construction of codes 3) System performance analysis 4) Numerical and simulation analysis 5) Conclusion 6) References.

2) Construction of codes:

2.1) Construction of DCS code:

We have developed a new code referred to as DCS, which includes the parameters *N*, *W* and λc , where *N* denotes the code length (i.e., the number of total chips), *W* the code weight, and λc indicates the in-phase cross-correlation. The cross-correlation λc between any pair of code sequences must be small enough. This property would ensure that each code sequence can be easily distinguished from every other address sequence. In other words, we seek to make the MAI which remains insignificant when compared to the energy contained in the information received. For code sequences $X = (x1, x2, ...xN)$ and $Y = (y1, y2, ...yN)$, the cross-correlation is given by

$$\lambda c = \sum_{i=1}^{N} xiyi$$

The codes with ideal in-phase cross-correlation ($\lambda c \leq 1$) are required in the OCDMA systems since these codes eliminate multi-user interference and suppress the effect of the PIIN. The technique utilised for constructing the DCS code is detailed further below.

2.1.1 Algorithm for DCS code design

The new code family suggested here is represented as ($N=\sum_{i=1}^{W-1} 2^{i} + D$, W , λ_c) where i=(0,1,……W-1), denotes a positive integer number and *D* represents the dynamic part. The next steps are followed to construct the DCS code words:

Step 1

First we construct a sequence S^i of integer numbers that are elements of the Galois field GF(*N*) = {1, 2,….., *N*} over an integer number *N*, using the expression

S^i = (2^i) (mod N) , i = 0,1

$(S^{i-1} + 2^i)$ (mod N) , i=2,3…… W-1 (1)

Here S^i, N, and W are the elements over the Galois field GF(N).

Step 2

After that we construct a sequence *Ti* of binary numbers (0, 1) basing on the generated sequence *Si* and using the mapping method

$$T_i=\begin{cases} 1 & for\ Si \\ 0 & otherwise \end{cases} \quad (2)$$

Step 3

Now we combine the binary sequence of each *Ti* that has been generated in the step 2, to get the first code sequence of the first user. The elements of the first code word are given by

$C_1 = T_0 + T_1 + T_2$ ………..T_{W-1} (3)

The method for producing the binary sequence (0, 1) based on GF(N) is shown in Fig. 1. We have also illustrated generation of the first DCS code word sequence in Table 1 for the codeparameters W = 3, D = 8 and N = 22 as an example. In Table 1, C_1 denotes the first code word of the DCS code. In Fig. 2.1.1 we display a procedure of combining the sequences Ti needed for generating the first code word of the DCS code.

i	S^i	T_i
0	1	10000000000000000000
1	2	01000000000000000000
2	6	00000100000000000000
3	14	11000100000001000000
C_1	C_1	11000100000001000000

Table 2.1.1. Generation of sequence Si and binary sequence Ti for the case of W = 4, D = 8 and N = 22.

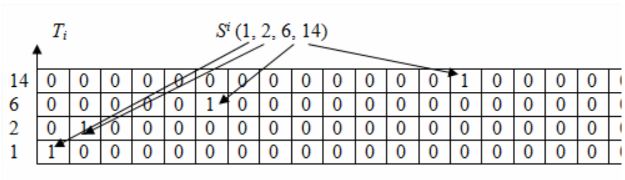


Fig. 2.1.1. Generation of sequence Ti for the case of N =22, D = 8 and W = 4

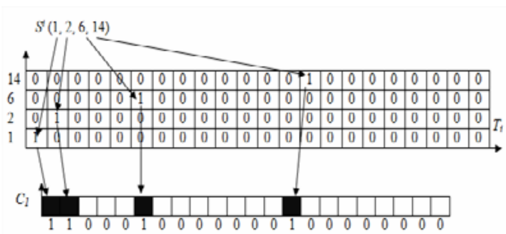


Fig. 2.1.2 Combination of sequences *Ti* used for producing the first code word

After generating the first code sequence, we use a cyclic shift method to produce the code sequence for the rest of the users. There are *N* – 1 different sequences which can be generated from the first code sequence. The number of the code sequences is equal to the code length ($K = N$). In order to achieve the cyclic shift property with a minimum cross-correlation ($\lambda c \leq 1$), we always consider the *D* values given by the inequality $D > 7$. Otherwise, the cross-correlation value would have been larger than one. In our code, the number of users can be increased by increasing the dynamic sequence *D* only, while the weight sequence part remains unchanged. An example is presented in Table 2 for $K = 14$ subscribers, where $W = 3$ and $D = 8$.

Table 2.1.2 shows the weight *W*, the code length *N*, and the cross-correlation λc for 30 users. It is clearly seen that the DCS code can be generated with lower code weights (*W* =2) and less lengths, when compared to the other codes. It is also seen that the DCS code reveals better crosscorrelation values ($\lambda c \leq 1$). Furthermore, if the chip width (i.e., the filter bandwidth) of 0.8 nm is used, the spectral widths required for the OOC, RD, MDW, MQC, KS, MFH and DCS codes are 291.2, 28, 44.8, 72, 115.2, 33.6 and 24 nm, respectively. As evident from Table 2.1.2, there is no other code that can be generated with the code weight equal to two, except of the DCS code

Suscriber code word
C_1= { 1 1 0 0 0 1 0 0 0 0 0 0 0 0 }
C_2={ 0 1 1 0 0 0 1 0 0 0 0 0 0 0 }
C_3= { 0 0 1 1 0 0 0 1 0 0 0 0 0 0 }
C_4= { 0 0 0 1 1 0 0 0 1 0 0 0 0 0 }
C_5= { 0 0 0 0 1 1 0 0 0 1 0 0 0 0 }
C_6={ 0 0 0 0 0 1 1 0 0 0 1 0 0 0 }
C_7={ 0 0 0 0 0 0 1 1 0 0 0 1 0 0 }
C_8={ 0 0 0 0 0 0 0 1 1 0 0 0 1 0 }
C_9={ 0 0 0 0 0 0 0 0 1 1 0 0 0 1 }
C_{10}={ 1 0 0 0 0 0 0 0 0 1 1 0 0 0 }
C_{11}={ 0 1 0 0 0 0 0 0 0 0 1 1 0 0 }
C_{12}={ 0 0 1 0 0 0 0 0 0 0 0 1 1 0 }
C_{13}={ 0 0 0 1 0 0 0 0 0 0 0 0 1 1 }
C_{14}={ 1 0 0 0 1 0 0 0 0 0 0 0 0 1 }

Table 2.1.2 DCS code words for the case of $W = 3$, $D = 8$ and $K = 14$.

2.2) Construction of FCC code:

Optical codes are family of *K* (for *K* users) binary [0, 1] sequences of length *N*, code weight *W* (the number of “1” in each codeword) and the maximum cross-correlation, ∂max. In OCDMA system, to allow receivers to distinguish each of the possible users, to reduce channel interference and to accommodate large number of users, optical codes should have large values of W and the size K.

Step 1;
The set optical code consists of (N, W, ∂max) FCC code for K users. The KxN code matrix A_K^w is here called the **Tridiagonal Code Matrix.** These sets of codes are then represented by;

$$A_K^W = \begin{matrix} a11 & a12 & a13 & 0 & 0 & \dots & 0 \\ a21 & a22 & a23 & a24 & 0 & \dots & \vdots \\ 0 & a32 & a33 & a34 & a35 & 0 & \vdots \\ 0 & 0 & a43 & a44 & a45 & a46 & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & \dots & \dots & \dots & \dots & aKN \end{matrix}$$

$$= \begin{matrix} A_1 \\ A_2 \\ .. \\ \dots \\ A_K \end{matrix} \quad (1)$$

Where

$A_1 = a_{11}, a_{12}, a_{13}.............a_{1N}$

$A_2 = a_{21}, a_{22}, a_{23}, a_{24}.........a_{2N}$

$A_3 = a_{31}, a_{32}, a_{33}, a_{34}, a_{35}....a_{3N}$

$\vdots$

$A_K = a_{k1}, a_{k2}, a_{k3}..............a_{KN}$

The rows of A1, A2 and Ak represent the K codeword and it is assumed that, the code weight of each of the K codeword is to be W.

Step 2;
After the K codes represented by the K rows of the KxN code matrix in equation (1), are to represent a valid set of K codeword with in phase crosscorrelations A_K^W max and code weight W; it must satisfy the following conditions:

1.The elements {aij} of A_K^W must have values "0" or"1"

$$a_{ij} = \text{"0" or "1" for } i=1,2,..K, j=1\ 2,.....N \quad (2)$$

2. The in phase cross-correlation λmax, between any of the K code words (K rows of the matrix, A_K^W) should not exceed code weight W. That is,

$$X_i X_j^T = \begin{cases} \leq \lambda \max \ for\ i \neq j \\ = W \quad for\ i = j \end{cases} \quad (3)$$

3. The code weight of each codeword should be equal to W where,

$$\sum_{j=1}^{N} a_{ij} = W \ , i=1,2,....K \quad (4)$$

4. From equation (3), it is seen that the $W = X_i X_i^T$ is the in phase auto-correlation function of codes. $X_i Y_j^T$ is the out of phase cross-correlation between the ith and the jth codes. It follows that $X_i X_i^T$ should be greater than $X_i Y_j^T$. In other words, $W > \lambda max$.

5. All K rows of A_K^W should be linearly independent because each codeword must be uniquely different from other codewords. That is to say the rank of the KxN matrix, A_K^W should be K. Moreover, for ,A_K^W to have rank K, thus codes $N \geq K$.

Step 3;

From the five conditions above in **Step 2**, one of the matrices binary sequences as shown in equation (1) in **Step 1**, whose the first ith row for the first K user is given by;

$$A_i = \underset{r\,(i-1)}{0.....0}\quad \underset{(w)}{11....1}\quad \underset{(K-i)}{0......0}$$

The length N of the codes which is the length of the rows of the KxN code matrix, A_K^W is given by;

$$N = WK - \lambda max\ (K-1) \quad (5)$$

It can be seen that the length N is minimum under the assumed conditions. Table 1 shows the FCC code for a given number of users K=5, weight W=4 and flexible crosscorrelation λmax ≤1

.

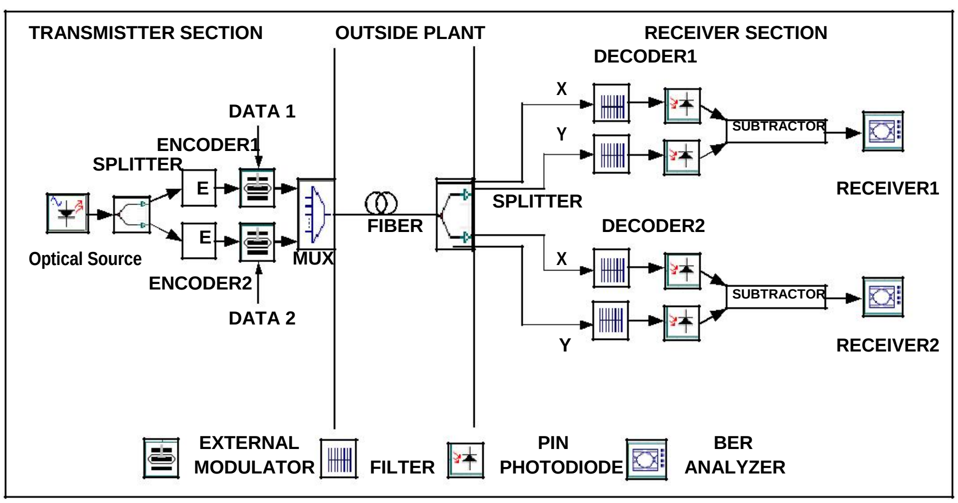
K1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
K2	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
K3	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
K4	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
K5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
A_i=	r(i-1)		|	W		|	r(K-i)									

Table 2.1: Example of FCC code

3) System performance analysis:

3.1) AND subtraction Detection technique for DCS:

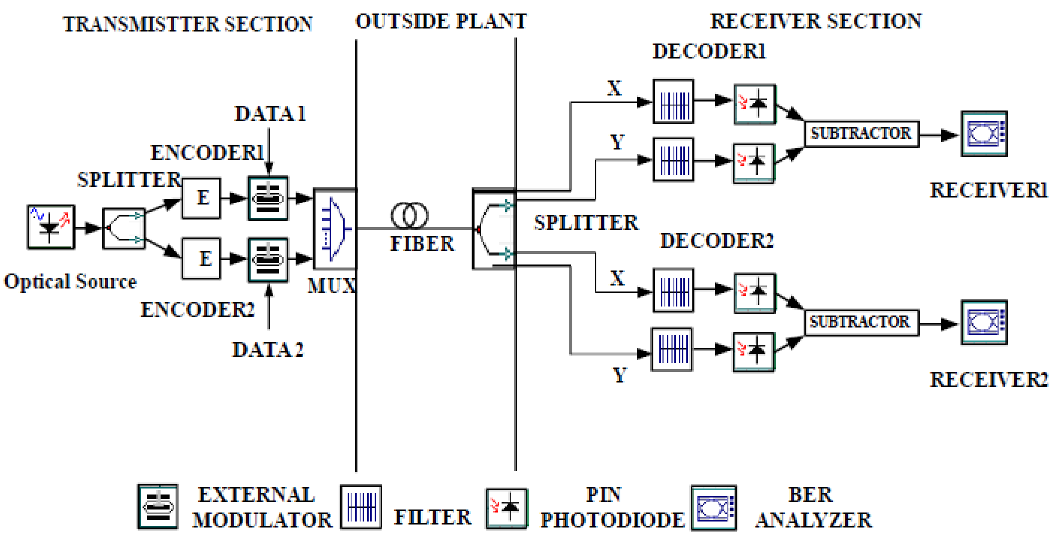
The AND subtraction technique has been used as a detection method. This technique is fully capable of eliminating the MAI, reducing complexity of receiver and improving performance ofthe system. In the frame of this technique, a spectral amplitude signal at the receiver side is split into two branches. The upper branch is the signal for a user X associated with cross-correlation between X and Y, and the lower branch should be a cross-correlation result from the AND operation between X and Y, which have the same cross-correlation magnitude associated with the signal in the upper branch.



3.2) AND subtraction Detection technique for FCC

The AND subtraction Detection technique has been used as a detection method. This technique is fully capable of eliminating the PIIN, less complexity of encoder and decoder design thus improving performance of the system.

The spectral amplitude signal at the receiver side is split into two parts. The first part is the signal for a user X related to crosscorrelation between X and Y, and the second part should be across-correlation result from the AND operation between X and Y, which have the same cross-correlation amplitude related to the signal in the first part.



4) Numerical and Simulation analysis:

4.1) Numerical analysis:

The performance of the DCS code has been compared numerically with the recently suggested codes such as the KS code, the EDW code, the MFH code, FCC . We evaluate the BER and the SNR using

$$SNR=\frac{1}{\sigma^2}=\frac{\left\{ RP_{sr}(W-1)/N \right\}^2}{\frac{eBRP_{sr}(W+3)}{N}+\frac{BR^2P^2_{sr}KW(W+3)}{N^2\,\Delta v}+P^2_{sr}R^2m^6_{n,k}\left[\frac{D_{1,1,1}}{32}+\frac{D_{2,1}}{64}\right]+\frac{4K_bT_n}{R_L}}$$

Here $D_{1,1,1}$ is the three-tone third-order inter-modulation at $fi + fK - fl$, and $D_{2,1}$ represents the two-tone third-order inter-modulation at $2\, fi - fK$

$$BER=\frac{1}{2}erfc(\sqrt{SNR/8})$$

Typical parameters used in our numerical analysis and calculations

Symbol	Parameter	Value
η	Quantum efficiency of photo-detector	0.6
P_{sr}	Broadband effective power	–10 dBm
B	Electrical bandwidth	80 MHz
λ_o	Operating wavelength	1550 nm
R_b	Data bit rate	155 M bit/s
T_n	Receiver noise temperature	300 K
R_L	Receiver load resistor	1030 Ω

Fig shows the relationship between the number of simultaneous users and the BER for the DCS and FCC code having W=4 . It is clearly seen that the performance of the DCS code is much higher when compared to the FCC codes. The maximum acceptable BER is 10–9 that we achieved by the DCS code compared. We can ascertain from this fact that the DCS code has a small length, the number of the active users is equal to the code size and the cross-correlation is $\lambda c = 1$ or $\lambda c = 0$,

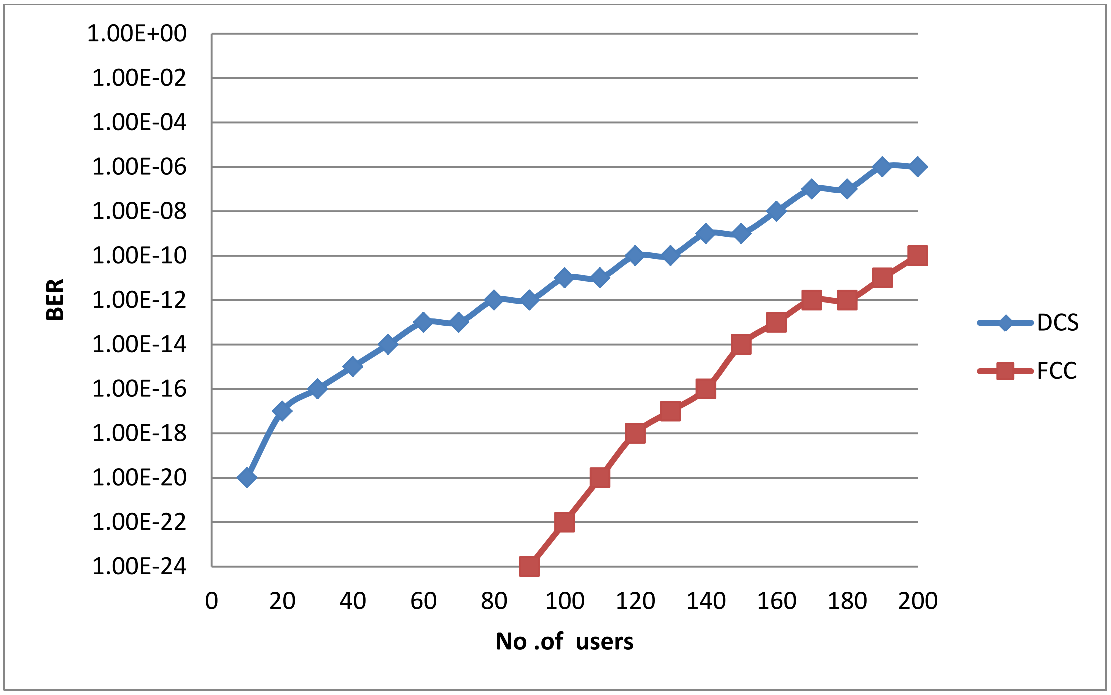


Fig: The relationship between the number of simultaneous users and the BER for the DCS and FCC code having W=4

4.2) Simulation analysis:

The hybrid system has been simulated using the software "*OptiSimTM*", The simulation is implemented for the two-subcarrier channel basing on the DCS and FCC code. Here we adopt the data rate 155 Mbit/s for each subcarrier channel. Furthermore, the subcarrier frequencies are set to be equal or larger than two times (the Niquest frequency) the bit rate. Each optical channel has the spectral width of 0.8 nm. The simulation has been carried out for a standard single-mode optical fibre ITU-T G.652. All the parameters that describe the attenuation (0.25 dB/km), the dispersion (18 ps/(nm km)), the nonlinear effects (four-wave mixing and self-phase modulation), have been activated and specified according to their typical industrial values, in order to simulate a real environment as close as possible. The noise generated at the receivers has been set to be random and totally uncorrelated. The dark current value has been put to be 5 nA. We have also used the thermal noise coefficient 1.8×10–23 W/Hz for each of the photo-detectors. The performance of the system has been characterised by referring to the BER and the eye diagram pattern. The effect of fibre distance on the performance of our system having two subcarrier frequencies for different light source powers. It is clear that the dispersion has significant impact on the system performance when the fibre length increases. Our simulation results indicate that the system performance is deteriorating by about more than one order of magnitude, whenever the dispersion effect is activated in the simulation model. In addition, our results testify that the system performance is worsening as the fibre length increases from 20 to 50 km. The fig shows the PIIN for DCS and FCC code that DCS code will eliminated MAI(multiple access interference) and improve BER (bit error rate) , PIIN(Phase induced intensity noise) and make orthogonality between users in the system.

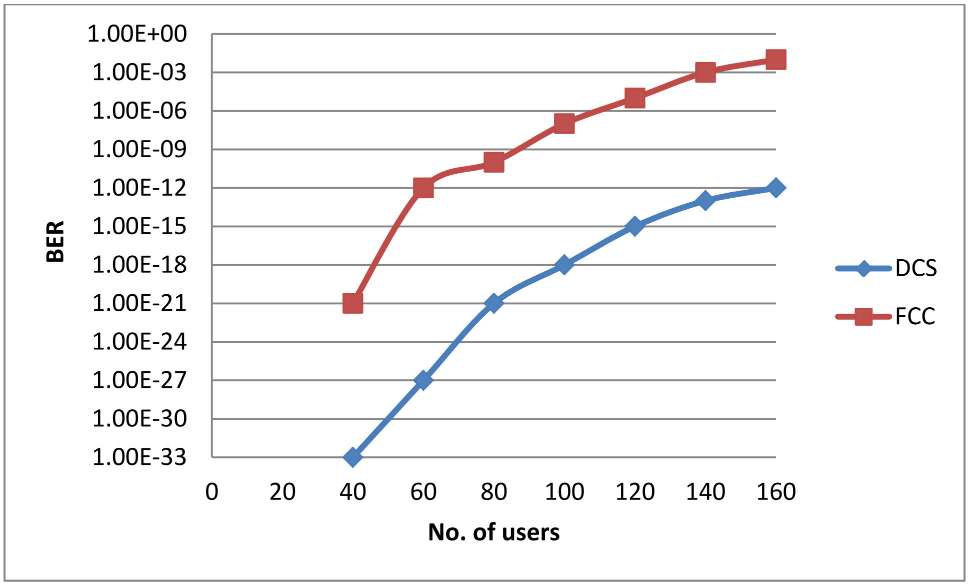


Fig: The relationship shows PIIN between the number of simultaneous users and the BER for the DCS and FCC code

5) Conclusion:

The system degradation due to *PIIN* can be suppressed using flexible cross-correlation property offered by FCC code and DCS , results in enhancing BER performance. The proposed DCS code is robust in term of received power, Psr as well as a reliable number of simultaneous users. The performance of the proposed DCS code achieves high cardinality (number of simultaneous users) and low received power in comparison to FCC code. The performance of the system is revealed to improve significantly, because the total loss is reduced as the AND detection technique requires less number of filters in the decoder. In addition, making use of the code words with less crosscorrelation value mitigates the PIIN, which improves the overall system performance. It suppresses the MAI, as compared to the system that uses the other SAC codes, and
enables carrying large numbers of code words and subcarrier channels.

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