Analysis of FCC & PN Codes for Smart Optical Communication

Anurag Paliwal[1] Navneet Agrawal[2] Ashik Husain[3]
[1]PhD Scholar [2]Professor [3]Head of Department
[2]Department of Electronics & Communication Engineering [3]Department of Computer Science & Engineering
[1,3]CPU, Kota, Rajasthan [2]CTAE, MPUAT, Udaipur Rajasthan

Abstract— FCC and PN sequences are generally called as spread spectrum codes. As we know that for optical communication, provider have to keep one thing clear that communication loss should be as minimal as possible. For which high signal quality and power level at receiver end must me encountered. The FCC and PN codes are generally used at transmitter end to spread signal over the available bandwidth so that one can not identify use full signal sended by the transmitter without despreding algorithm. here in this paper generation and principle of above mention codes are analyzed

Key words: DCF (Dispersion Compensating Fiber), Electronic Equalizer, BER (Bit error rate), Q-factor, Eye Height, Threshold, FCC (Flexible cross correlation), PN (Pseudo Random)

I. Introduction

In a communication system, each user transmits an assigned code whenever a bit of "1" is to be transmitted and does not transmit anything whenever a bit of "0" is to be transmitted. In any type of communication the most important consideration is the code design; improperly code designed and higher number of simultaneous users can be badly degraded the system performance due to existing of Multi User Interference (MUI) The proposed research paper utilizing FCC code has been analyzed with the PN code. It has been assumed that the in phase cross-correlation value can be flexible which ensures that each codeword can be easily distinguished from every other address sequence. The code is optimum in the sense that the code length is shorter for a given in phase cross-correlation function. The FCC code can be constructed with simple Tri diagonal matrix property, given any number of users and weights.

II. FCC Code Development

Optical codes are family of K (for K users) binary [0, 1] sequences of length N, Hamming-weight w (the number of "1" in each codeword) and the maximum cross-correlation, λ max. The optimum code set is one having flexible cross-correlation properties to support the maximum number of users with minimum code length. This ensures guaranteed quality of services with least error probabilities for giving number of users K at least for the short haul optical networking. Now, let A= {an} and B= {bn} be the sequences of length N such that;

$$\{a_i\}=\text{'0' or '1'}, i=0,\ldots\ldots N-1\}$$
$$\{b_i\}=\text{'0' or '1'}, i=0,\ldots\ldots N-1\}$$

The auto and cross-correlation functions of these sequences are defined, respectively

$$\lambda_a(\tau)=\sum_{i=1}^{N} a_I a_{i+\tau=W \text{for} \tau=0}$$
$$\lambda_{ab}(\tau)=\sum_{i=1}^{N} a_i b_{i+\tau \leq 1 \text{for} \tau=0}$$

Since a_n is a {0, 1} binary sequence, the maximum value of λa (τ) in equation is for τ=0 and is equal to w, the Hamming-weight of the sequence can be expressed as;

$$\lambda a(0)=w$$

If λam & λabm denote the maximum out of phase auto–correlation and cross-correlation values respectively, then an optical code of length N and Hamming-weight w can be written as (N,w,λam, λabm). A (N,w,λam,λabm)- for FCC code is called the constant- weight symmetric FCC when λa =, λab = λmax, and we used the shorthand notation of an (N, w, λmax) for the largest possible cardinality (number of users). It may also be noted that for an optical code a_n with Hamming-weight 'w' for auto-correlation can be written as follows:

$$\lambda_{amax}=\lambda_a(0)=\sum_{n=0}^{N-1} a_i a_i=w$$

In practice for K users, it is required to have a K number of codes in a set for given values of (N, w, λmax). The codes described by equation can also be represented in vector form as;

$$A=\{a_i\} \text{fori}=0,1\ldots\ldots N-1$$
$$B=\{b_i\} \text{fori}=0,1\ldots\ldots N-1$$

Where, A and B are vectors of length N with elements as defined by given In terms of the vectors A and B, equations and can be written as;

$$\lambda_A(0)= AA^T = W$$
$$\lambda_{AB}(0)=AB^T$$

Where A_T and B_T denote the transpose of vectors A and B, respectively.

III. Algorithm for FCC Code Design

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. For better communication and 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.

A. 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;

$$A_K{}^W= \begin{matrix} a11 & a12 & a13 & 0 & 0 & \ldots & 0 \\ a21 & a22 & a23 & a24 & 0 & \ldots & \vdots \\ 0 & a32 & a33 & a34 & a35 & 0 & \vdots \\ 0 & 0 & a43 & a44 & a45 & a46 & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & \ldots & \ldots & \ldots & \ldots & aKN \end{matrix} = \begin{matrix} A1 \\ A2 \\ A3 \\ \vdots \\ \vdots \\ AK \end{matrix}$$

Where

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

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

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

⋮

$A_K = a_{k1}, a_{k2}, a_{k3}, \ldots\ldots\ldots\ldots\ldots a_{KN}$

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

B. Step 2

After the K codes represented by the K rows of the KxN code matrix in equation are to represent a valid set of K codeword with in phase cross correlations 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" aij="0"or"1"for*i*=1,2,..*K*,*j*=1,2,…..*N*
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,
$$XiXj^T = \begin{cases} \leq \lambda \max for\ i \neq j \\ = W \quad for\ i = j \end{cases}$$
3) The code weight of each codeword should be equal to *W* where,
$$\sum_{j=1}^{N} a_{ij} = W, i=1,2,\ldots.K$$
4) From above equation, it is seen that the $W = Xi\ Xi^T$ is the in phase auto-correlation function of codes. $Xi\ Yj^T$ is the out of phase cross-correlation between the *i*th and the *j*th codes. It follows that $Xi\ Xi^T$ should be greater than $Xi\ Yj^T$. In other words, *W*> *λmax*.
5) All *K* rows of A_K^W should be linearly independent because each codeword must be uniquely different from other code words. That is to say the rank of the *K*x*N* matrix, A_K^W should be *K*. Moreover, for ,A_K^W to have rank *K*, thus codes *N* ≥ *K*.

C. Step 3

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

A_i=0…..011….10……0 (4.14)

It can be seen that the length *N* is minimum under the assumed conditions. Table shows the FCC code for a given number of users *K*=4, weight *W*=3 and flexible cross correlation λmax ≤1 .

K1	1	1	0	0
K2	1	1	1	0
K3	0	1	1	1
K4	0	0	1	1

D. Generation of FCC Codes

Now the fig. describe the flow chart of FCC code. All the algorithm step is discuss in the form of flowchart to understand in easy way.

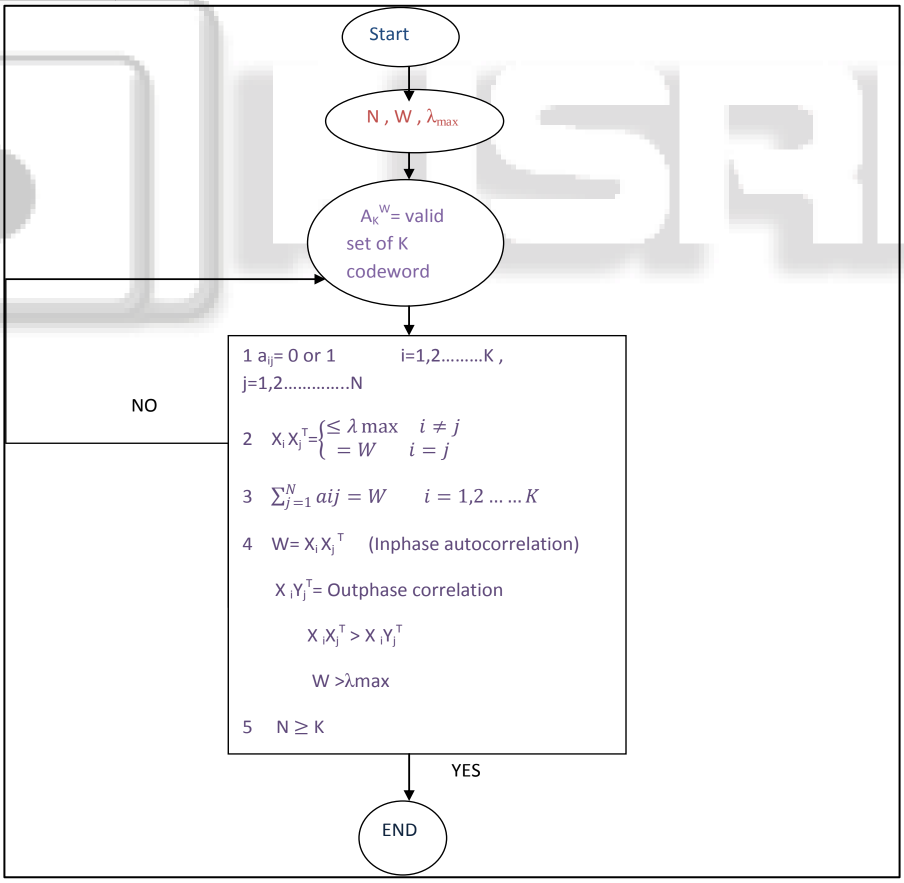


Fig. 1: Flow Chart of FCC Code

IV. INTRODUCTION TO PN CODE

A Pseudo random Noise Sequence is a binary sequence which however deterministically generated by a circuit or an algorithm appears to be statistically random like in the case of a fair coin flipping.

Traditional definition: In 1967, Golomb gave the following three properties:

– P1 Relative frequencies of 0_s and 1_s are each ½.
– P2 Run lengths are as expected in a coin flipping, i.e., $1=2^n$ of all the runs would be of length n.

– P3 If the sequence is shifted by any non zero numbers of bits, then the relative hamming distance between the two sequences would be half.

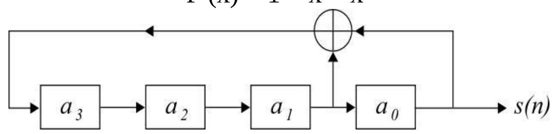
(P1 is known as Balance and P2 is known as Run) Any sequence which follow the above three properties within extremely small discrepancies can be called PN sequence

V. PN CODE GENERATION

Most of the PN sequences are easily implemented both on hardware as well as on software. In fact, they are usually categorized on the basis of generation method.

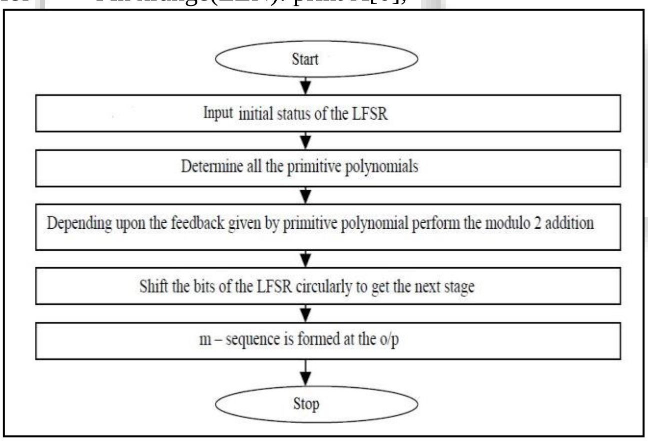
1) Using shift registers with feedback: Maximal Length Sequences or m-sequence is the class of PN sequences which can be generated by this method. A shift register for length n can generate a maximal length sequence of 2^n 1 bits. Consider the following circuit characteristic polynomial:

$$P(x) = 1 + x + x^4$$



Following is the software implementation for the same PN Sequence:

A = input() # first 4 bits input LEN = 15
for i in xrange(LEN): print A[0],



A = [A[1], A[2], A[3], A[0]^A[1]]

Fig. 2: Flowchart of PN sequence

VI. CONCLUSION

The spreading codes are playing vital role in the smart communication area therefore with this analysis of PN and FCC codes we are now on the right platform over which providers have lot of opportunities to achieve their goal as per the requirements of user .using such types of sequences one can easily establish his communication with high signal security.

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