SPREADING CODES

Ion POPA
Societatea Română de Televiziune –
Studioul Teritorial Iaşi

REZUMAT. În această lucrare am realizat un studiu al codurilor de împrăştiere pe baza caruia am conceput mai multe programe cu ajutorul cărora pot genera secvenţe de cod de tip M, Gold şi Gold ortogonal pentru care se poate calcula autocorelaţia şi corelaţia încrucişată Pe baza acestor informaţii,cei interesaţi îşi pot genera şi selecta propriile secvenţe de cod cu ajutorul carora pot realiza studii de performanţă prin simulare pe calculator atunci când au de proiectat diverse sisteme de comunicaţii mobile care folosesc tehnologia de acces multiplu cu divizare în cod (CDMA).

Cuvinte cheie: : autocorelatie ,corelatie incrucisata, secvente de cod.

ABSTRACT. In this paper we conducted a study of spreading codes based on which we have developed several programs with which code can generate the type M sequences, Gold and Gold, which is orthogonal to calculate autocorrelation and cross correlation. Based on this information, those interested in and choose their own way can generate code sequences with which they can achieve performance studies by computer simulation to design when different systems of mobile technology use in code division multiple access (CDMA).

Keywords: autocorrelation, cross correlation, code sequences.

1. INTRODUCTION

Develop communications and information processing technologies has opened more opportunities for new communication services. Stringent requirements of communications capacity are made in relation to the number of users that can be served simultaneously or in other words how much information is likely to be transferred. One of the ways they can increase the total data rate is to achieve a more efficient allocation of resources. In the case of mobile communications systems is the need for a large number of users can transmit and receive signals at once to one or more base stations. Because multiple users can simultaneously use the communications resources necessary to fix a way that these resources be allocated to each user. Technique which is divided by a common communications channel between multiple users is called multiple access. A multiple access system is shown in Fig .1 As seen from the figure, a number of users share a common communication channel in order to transmit information to a receiver. For example, common channel may be a common band of radio spectrum use for multiple users to communicate with the radio.

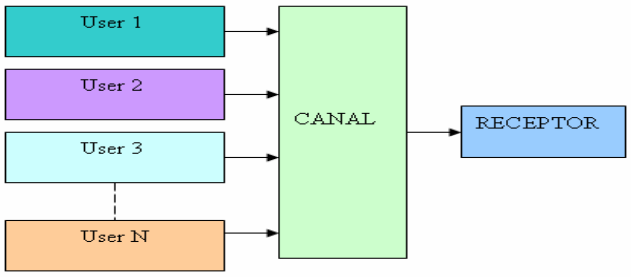

Fig.1 A multiple access system

In a communication system have a fixed amount of resources, the range that it must manage it properly so that all subscribers can be accommodated by the system. In environments with multiple access signals needed for different users are different from one another. At the same time each user`s signal must be identified by a "label" single that can be extracted (identified) corresponding to the reception. "Tag" user`s can be assigned to one of the areas: time, frequency (wavelength), or area code.

Depending on how communication resources are shared, multiple access techniques are classified as:

Frequency division multiple access (FDMA) assumes that each users specific frequency bands are allocated.

Time division multiple access (TDMA) different users are allocated different time slots.

Code division multiple access (CDMA). users distinguish adjustable single signature waveform (or code) that differ from one user to another.

Space division multiple access (SDMA) is explored spatial diversity.

The combination of these techniques can be obtained other methods called hybrid methods. Each multiple access technique has advantages and disadvantages compared to the other it depends on the application, the channel characteristics and other parameters.

2. COD DIVIZION MULTIPLE ACCESS (CDMA)

Implementation techniques with spread spectrum communications systems have led to the idea of code division multiple access. In other words we can not talk about with code division multiple access without also discuss the principles of **spread spectrum.**

Is a spread spectrum transmission signal occupies a bandwidth in excess of the minimum necessary to transmit information**.** Band scattering is achieved by means of a code that is independent of the data. De-spreading and then data recovery is done using the same code used to broadcast that synchronizes reception. CDMA protocols are a class of protocols in which multiple access capability is achieved through encoding.

In CDMA, each user is assigned a unique code sequence used to encode a signal. The receiver, knowing the user`s code sequence, decodes the received signal after reception and recovers the original date.

Because band encoded signal is chosen to be greater than the signal band information, coding process, expand (spread) signal spectrum and is therefore known as spread spectrum modulation (SS) and signal spreading codes used are called spreading codes.

3. PROPERTIES OF THE SPREADING CODE

In the choice sequence CDMA systems the code is so important for resistance against interference with other areas and against interference with multiple users. Sequences of code that needs to be as different but at the same time can be easily reproduced at the reception signal can be recovered.

There are two important properties of spreading sequences: Autocorrelation and cross correlation.

Autocorrelation sequence gives us a measure of how well or how bad it is related to a delayed version of signal. When multiple copies of the transmitted signal arrives at the receiver with time delays are different, each of them interfere with each other this leads to unpleasant results. Hence we conclude that to reduce the unwanted effect of delayed correlation between the signal and the copy should be as small as that is a near-zero autocorrelation. Even if a single code sequence is assigned to each user to a user signal still interferes with that of another user when the environment is accessible at the same time, this interference being called multiple access interference. This interference can be reduced by choosing sequences of code that have a small cross corelation. To cope with such interference, it must meet several requirements:

- Each code sequence must be periodic with a constant length.
- Each code sequence must be easy to distinguished from its time –shifted code.
- Each code sequence must be easy to distinguished from other code sequences .

The first two requirements are important because the effects of multiple propagation paths that occurs in the external environments and mobile internal radio. The third requirement is important because the ability to access multiple communication systems. To measure the level of distinction for the requirements of the codes (a) and (2), using the autocorrelation function and cross correlation. The simple random code sequences are those where each chip is selected randomly between "+1" and "-1"independence of each other and with equal probability. These sequences are known as pseudo-noise sequence (pseudo) PN.

Pseudorandom sequences are characterized by the following properties:

-The property of symmetry.

- the relatively frequencies for 0 and 1(zeros and ones weights) are 1 / 2.

- Ownership of the "long run".

Random binary sequences occur in groups of zero and one called "run lengths" to comply with the following rule: half of the run lengths are the size (length) unit, a quarter are of length two, one eighth are of length three one part $1/2^n$ is the length n for any n finite.

- Ownership of movement and assembly.

If the random sequence is traversed by any number of elements nonzero, the resulting sequence will have an equal number of coincidences and non coincidences original sequence. Pseudorandom sequences must meet the following conditions: - Sequences of numbers must be composed of two levels.

- Autocorrelation codes must have a maximum (the length of a chip) to enable synchronization code.

- Sequences must have a low value of cross correlation. The cross correlation is less that the more users will be able to communicate in the system.

- Sequences must be "balanced" or the difference between the numbers 1 and 0 in the code can be only one for the spectral energy density is distributed evenly in the band.

4. CALCULATION OF AUTOCORRELATION AND CROSS CORRELATION

Autocorrelation function is a periodic function is used to measure the level of distinction between the two code sequences and is defined by:

$$r(t) = 1/T \int X(t)X(t+\tau)d\tau \quad (1)$$

Autocorrelation function values are represented in figure 2 and are given by:

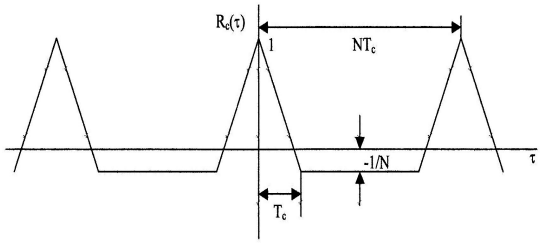

Fig.2. Autocorrelation function for a sequence with chip duration Tc and the period of NTc.

For MATLAB simulation of the autocorrelation function is denoted **"autocorr.m"** Arguments of this function are the name of the sequence and number of periods for which the code will get the autocorrelation function. For example, to calculate the autocorrelation function of the code X (t) = [1, 1, 1, -1, -1, 1, -1], must be given the following MATLAB command window:

>> X = [1, 1, 1, -1, -1, 1, -1];

>> Rxx = autocorr (x);

In our case, use an M sequence code of length 7, which will be described in this section. Autocorrelation value is 7 at t = T · k (k = 1, 2, 3, ...) and -1 othewise . Cross correlation function is the value of the correlation between different code sequences X (t) and Y (t). and is defined as:

$$r(t) = 1/T \int X(t)Y(t+\tau)d\tau \quad (2)$$

For MATLAB simulation cross-correlation function is denoted **"cross-corr.m."** Arguments of this function are the name of the sequence and number of times of code for which to obtain the autocorrelation function. For example, to calculate the cross correlation function codes X (t) = [1, 1, 1, -1, -1, 1, -1] and Y (t) = [1, -1, 1, - 1, 1, -1, 1] is the MATLAB window, type the following command:

>> X = [1, 1, 1, -1, -1, 1, -1];

>> Y = [1, -1, 1, -1, 1, -1, 1]

>> Rxx = crosscorr (xy);

In this case, use a random sequence of M and a sequence code of length 7. The correlation between the two codes is relatively small. Using the autocorrelation functions and cross correlation, one can evaluate the code spreading.

5. CODE GENERATION BY LINIAR FEEDBACK SHIFT REGISTERS.

In this section describes how sequences are generated using the MATLAB code and the characteristics of generated codes. For this study, we considered three types of code sequences, namely: M sequences, Gold sequences and orthogonal Gold sequences There are several ways to generate sequences of codes. One of the most commonly used method in CDMA systems is the method of generating sequences using feedback shift register. A shift register contains a number of cells (numbered 1 to r), and each cell is a storage unit under the control of pulse timing, moving its content to the exit while reading the new content came. The standard configuration of the register, entered the cell “m” will exit the cell m-1 function and cell output r (the last cell of the serial register) forming the desired code sequence. In this chapter there are several sequences generated by a linear circuit consisting of a feetback shift register .

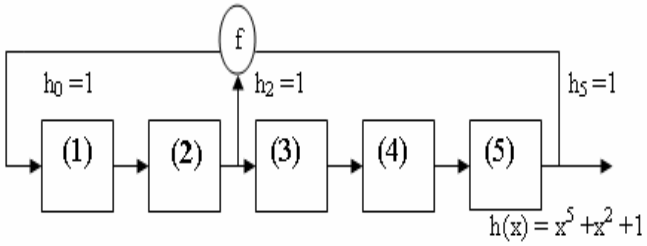

Fig. 3 A single liniar binary shift register

Fig.3 presents a linear circuit consisting of a serial register and a reaction function that can generate a sequence from a generator polynomial h (x) = x5 + x2 + 1. Usually, setting up a linear circuit consisting of a serial register and a year depending on the reaction section is described by a generator

polynomial is a binary polynomial of degree n. The number n is the number of shift-register sections.

$$h(x) = h_n x^5 + h_{n-1}x^{n-1} + h_1 x^1 + 1 \ (h_i \in \{0,1\}) \quad (3)$$

In Fig. 3, $h(x) = x^5 + x^2 + 1$, $h_0 = h_2 = 1$, iar $h_n = 0$. Using this registry, we can generate many sequence spreading codes.

6. M-SEQUENCE

M sequences are generated by a single linear circuit comprising a serial register and a reaction function. In particular, a sequence with maximum period possible ($Nc = 2^n - 1$) is generated by a register serial linear binary. shift register. To generate an M sequence, the generator polynomial must be a polynomial of degree n. The periodic autocorrelation function of a sequence M is given by:

$$r(t) = 1/T \int x(t)x(t+\tau)d\tau \quad (4)$$

with the following values:

$$r(t) = 1 \text{ for } t = 0,N,2N. \quad .$$
$$\text{and } -1 / N \text{ otherwise} \quad (5)$$

If n is different from 0 modulo 4. There are four pairs of maximum length sequences have three values for the cross-correlation function. These values are: {-t(n), -1, t(n) -2} with:

$$t(n) = 1 + 2^{(n+1)/2} \text{ for n = odd}$$
$$1 + 2^{(n+2)/2} \text{ for n = hair} \quad (6)$$

Generating function is denoted as M sequences „**mseq.m"** The number of registry , initial values of the registers and position of the back bits are given as arguments for „**mseq.m".** For example, suppose that the number of registers is 3, the initial values of the registers are [1, 1, 1], and bit position of the reaction between the first and third bit. Generator polynomial is expressed as h (x) = x3 + x + 1. Serial Configuration register for generating a sequence M is shown in Fig. 4.

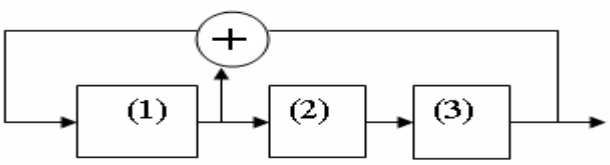

Fig. 4 A three-stage M-sequence

When I generate a sequence using a generator polinon, the following command:

>> m1 = msec (3, [1, 3], [1, 1, 1])

Therefore, the sequence M Grade 3 [1, 1, 1, 0, 1, 0, 0] is generated as a vector. Thus, mseq.m. is the fourth argument indicates the number of exits. If the number of outputs, is N, N sequence can be obtained with chip shifted. For example, another grade 3 M sequence is generated using the following command:

>> m2 = mseq (3, [2, 3], [1, 1, 1], 3)

When applying this command, you get those sequences.

ans =
1 1 1 0 0 1 0
0 1 1 1 0 0 1
1 0 1 1 1 0 0

Using functions and "**crossorr.m**" "**autocorr.m**" can be measured characteristics of the sequences. Becouse sequences that contain 0 and 1, sequences of code are converted into code sequences containing -1 and 1 by the following command:

>> m1 = m1*2-1;
>> m2 = m2*2-1;

Autocorrelation function of the sequence M is calculated using the following command:

>> autocorr (m1)

Therefore, we obtain a value of autocorelației of [7, -1, -1, -1, -1, -1, -1]. Then the cross correlation value is obtained [3, -1, 3, -1, -1, -5, 3]. This result has three values, namely [-1,-t (n), t (n) -2] where t (n) = 5. Thus, m1 and m2 have the characteristics of a favorite pair. The number of sequences M is very small. With sequences M, you can set other sequence spreading codes.

7. GOLD SEQUENCE

M sequence has good autocorrelation characteristics. However, the number of mobile communication systems using M sequence is very low. This is because the number of sequences M which have the same code length and the same autocorrelation characteristics is limited. When performing a CDMA system where multiple users communicate with one another, it takes several different coding sequences which have the same correlation. Gold sequence is such a sequence. Gold sequence was developed by Gold. It is generated by OR operation (EX-OR) two M sequences whose relationship is that of a favorite pair. Generation circuit using a linear circuit in three stages and is shown in Figure 5.

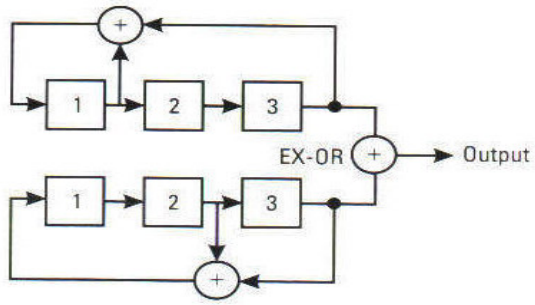

Fig.5. Athree-stage Gold sequence

The Gold sequence generated from two sequences of M, the cross correlation has three values ie{-1,-t (n), t(n) -2}. Generating function of a Gold sequence is denoted as"**goldseq.m"**. To generate a Gold sequence, we use two M-type sequences. For example, to generate a Gold sequence, must be made the following commands:

```
>> m1 = mseq (3, [1, 3], [1, 1, 1]);
>> m2 = mseq (3, [2, 3], [1, 1, 1]);
>> g1 = goldseq (m1, m2)
```

Therefore, one can obtain a Gold sequence in three stages [0 0 0 0 1 1 0] vector of length 7. Changing the original data, it can get a different Gold sequence. To calculate the cross correlation, it generates another Gold sequence.

```
>> m3 = mseq (3, [1, 3], [1, 0, 0]);
>> m4 = mseq (3, [2, 3], [1, 0, 1]);
>> g1 = goldseq (m3, m4)
```

In this case, goldseq.m is the third argument indicates the number of exits.. If the number of outputs, N, is given as the argument, we get a number N Gold sequences. For example, when performing the following command:

```
>> g1 = goldseq (m1, m2, 3)
```

Gold three sequences are obtained:

```
ans =
0 0 0 0 1 1 0
1 0 0 1 1 0 1
0 1 0 1 0 0 0
```

Using functions and crossorr.m autocorr.m can be measured characteristics of a Gold sequence. In our case, we obtain a value of the autocorrelation function [7, 3, -1, -1, -1, 3]. The value of the autocorrelation function has a high value at the point of synchronization. But in other respects, the data fluctuates. Then, we obtain the cross correlation value of g1 and g1 the following command:

```
>>crosscorr (g1, g2)
```

Finally, we get the value of [-1, 3, -1, -5, -1, 3, -1]. This result has three values: {-1,-t (n), t (n) -2}, where t (n) = 3.

8. ORTOGONAL GOLD SEQUENCE

Gold sequence has several different coding sequence compared with those of M. However, there are a number of problems associated with Gold sequence:

-Proporția de 0 la 1 nu este întotdeauna echilibrată.

-Value, cross correlation of Gold sequence is not 0 in a synchronized environment.

-Code length is an odd number

As a result, special synchronization is required for generating Gold sequences. To solve the above problems, add a chip from Gold sequence to balance the proportion of 0 and 1. This sequence is called orthogonal Gold sequence. Value, cross correlation of the orthogonal Gold sequence is 0 at the point of synchronization. In other points, the sequence features are similar to those of the Gold sequence.

9. RESULTS OBTAINED BY SIMULATION

9.1. Calculation of autocorrelation function for M- sequences

To calculate the autocorrelation function we have developed a program which can calculate the autocorrelation using the different code sequences noted in the program: **indata.** Call results presented below.

```
for indata = [1,1,1, -1, -1,1,1]
ans =  7  3 -1 -1 -1 -1  3
for indata = [ 1,1,1,-1,-1,1,-1]
ans = 7    -1    -1    -1    -1    -1    -1
for indata = [ 1,1,1,-1,1,1,1]
ans =7     3     3     3     3     3     3
for indata = [ 1,1,1,1,1,1,1]
ans = 7     7     7     7     7     7     7
for indata = [ -1,-1,-1,-1,-1,-1,-1]
ans =  7     7     7     7     7     7     7
for indata = [ 1,1,1,-1,-1,1,1]
ans = 7    -1    -5     3     3    -5    -1
for indata = [ -1,1,1,-1,-1,1,-1]
ans = 7    -1    -5     3     3    -5    -1
```

From the examples above we see that the best sequence is: indata = [1,1,1,-1,-1,1,-1] because the value is the maximum duration autocorelației a chip and this value is 7 and the value is -1 otherwise. Sequence, the bad is: indata = [1,1,1,1,1,1,1], which has the maximum value for the whole autocorrelation sequence length.

9.2. Calculation of cross-correlation function for M- sequence:

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = -1 3 -1 3 -5 3 -1

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = 1 1 1 1 -3 1 1

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = 3 -1 3 -1 -1 3 -1

Cu : indata 1 = [1,1,1,-1,-1,1,-1] şi indata 2 = [1,-1,1,-1,1,-1,1]
ans = 1 1 1 1 1 1 1

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = 1 1 1 5 -3 1 -3

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = -1 -1 3 3 -1 3 -1

for indata 1 = [1,1,1,-1,-1,1,-1] and indata 2 = [1,-1,1,-1,1,-1,1]
ans = 1 1 1 1 1 1 1

From the above calculations we see that we get the best correlation when sequences are balanced (the number of 1 and -1 differ by one unit). In our case the best correlation is obtained for:

indata1 = [1,1,1,-1,-1,1,-1] and indata2 = [1,-1,1,-1,1,-1,1].

9.3. Generating M- sequences

Register with one output:
ans = 1 1 1 0 1 0 0
Register with two outputs:
ans = 1 1 1 0 1 0 0
0 1 1 1 0 1 0
Register with three outputs:

ans = 1 1 1 0 1 0 0
0 1 1 1 0 1 0
0 0 1 1 1 0 1

Register with four outputs:

ans = 1 1 1 0 1 0 0
0 1 1 1 0 1 0
0 0 1 1 1 0 1
1 0 0 1 1 1 0

From the examples above we noticed that when using a serial register to generate sequences that I can have multiple outputs. So can I get a number of sequences have so many users in the system. Number of users of the system operating at a given time can not be bigger than the code sequence length. In our case the code sequence length M is 7 so the number of users on the system must be up to 7.

10. CONCLUSIONS

Based on this information can generate different code sequences type M, Gold, and Gold, which is orthogonal to calculate autocorrelation and cross correlation to select the best sequences of code that can be used in mobile communications systems using wireless technology the code division multiple access (CDMA). Those interested can create their own way using code sequences that can carry out studies of mobile communications systems performance by computer simulation.

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