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Noise Effective Code Analysis on the Basis of Correlation in CDMA Technology

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ABSTRACT

The wireless communication system has grown extremely fast over the past few decades, with the demand doubling roughly every two years. Consumers today have access to many different kinds of wireless services, having widely varying range of coverage. Short-range services include cordless telephones and wireless local area networks (WLANs). Long-range products include satellite based wireless units. In various intermediate ranges there are products such as cellular telephones, wide-area wireless data and radio paging services, specialized satellite-based message services in the freight industry and internet-access from handheld units. Clearly, wireless communication today encompasses many technologies, systems and services, aimed at many different applications of these. The most widely used wireless communication is cellular mobile radio systems. Basically, CDMA system is noise limited, not bandwidth limited. Because the capacity of the CDMA system depends on signal to noise ratio. if it is possible to minimize the noise by using the special types of codes than general used code the system will be more reliable. In the telecommunication the word noise is used as a label for the electrical distribution that gives rise to audible noise in a system. It is a fact that the noise is a great problem in the telecommunication sector. The Walse Code which is used in traditional CDMA system is not so much effective in huge noisy environment compared with the Gold Code.

Keywords: CDMA, Spread Spectrum, PN Code, Gold Code, Walsh Code, Random noise generator, Code Generators.

1. INTRODUCTION

1.1 Basic Principle of CDMA

The first CDMA networks were commercially launched in 1985, and provide roughly 10 times more capacity than analog networks - far more than TDMA or GSM. Since then, CDMA has become the fastest-growing of all wireless technologies, with over 100

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million subscribers worldwide. Code Division Multiple Access (CDMA) implemented with direct-sequence (DS) spread spectrum constitutes one of the most important emerging technologies in wireless communications. In addition to supporting more traffic, CDMA brings many other benefits to carriers and consumers, including better voice quality, broader coverage and stronger security.

A CDMA receiver separates the signals by means of a correlator that uses the particular binary sequence to despread the signal and collect the energy of the desired signal. Other users' signals, whose spreading codes do not match this sequence, are not despread and as a result contribute only to the noise. The output of the correlator is sent to a narrow-bandwidth filter. The filter allows all of the desired signal's energy to pass through, but reduces the interfering signal's energy–to-interference ratio of the desired signal. This ratio is also known as the processing gain.

2. PSEUDO NOISE CODE

2.1 Spread Spectrum

Spread spectrum techniques involve spreading the bandwidth needed to transmit data, which does not make sense at first sight. Spreading the bandwidth has several advantages. The main advantage is the resistance to narrowband interference. The energy needed to transmit the signal is the same, but it is now spread over a large frequency range. The power level of the spread signal can be much lower than that of the original narrowband signal without losing data.

During transmission, narrowband and broadband interference are added with the signal. The sum of interference and user signal is received. The receiver now knows how to despread the signal, converting the spread user signal into a narrowband signal again, while spreading the narrowband signal again, while spreading the narrowband interference and leaving the broadband interference. The receiver applies a band pass filter to cut off frequencies left and right of the narrowband signal. Finally, the receiver can reconstruct the original data.

2.2 PN Code

A pseudo-noise (PN) code sequence is a periodic binary sequence with noiselike waveform but have deterministic value. The codes are usually generated by means of feedback shift registers. The selection of good code is important, because types and length of the code sets bound on the system capability. The PN code sequence is a pseudo noise or pseudo random sequence of 1's and 0's, but not a real random sequence (because periodic). The autocorrelation of a PN code has properties similar to those of white noise [2].

■ **Pseudo-Random Property**

- The code is not random. But it appears random for the user who does not know the code.

- The code is deterministic, periodical signal that is known to both the transmitter and the receiver. The longer the period of spreading code, the closer the transmitted signal be a truly random binary wave and the harder to detect.
- It has statistical properties like the sampled white noise.

2. 3 Three special type Pseudo Noise Code

2.3.1 Gold Code

The cross-correlation function between the spreading codes assigned to any two users of the system be zero for all cyclic shifts. For this shortcoming of ordinary PN sequences, a special class of PN sequences called Gold Sequences (Codes) is used.

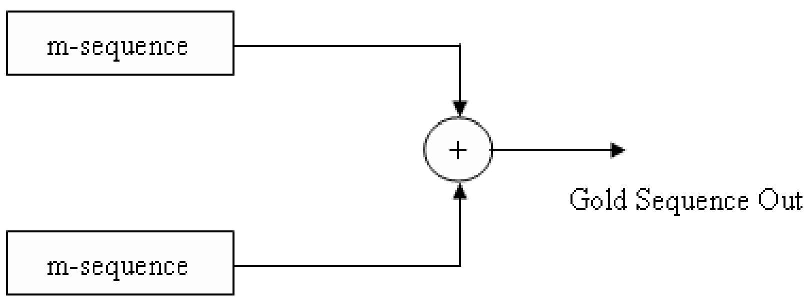

Figure 1. Block diagram of Gold code generator

2.3.1.1 Gold Theorem

Let g_1(X) and g_2(X) be a preferred pair of primitive polynomials of degree n whose corresponding shift registers generate m-sequence of period 2^n-1 and whose cross-correlation function has a magnitude less than or equal to

$2^{(n+1)/2}+1$ for n odd, or

$2^{(n+2)/2}+1$ for n even and n≠0 mod 4.

Then the shift registers corresponding to the product polynomial g_1(X). g_2(X) will generate 2^n+1 different sequences, with each sequence having a period of 2^n-1.

2.3.1.2 Correlation properties of Gold Code Sequences

Here a period of 2^n-1 =127 is considered. To generate such sequence for n=7, it needs a preferred pair of PN sequences that satisfy as

$$2^{(n+1)/2}+1=2^4+1=17$$

This requirement is satisfied by the PN sequences with feedback taps[7,4] and [7,6,5,4]. The gold sequence generator is shown in figure. According to Gold's theorem there are a total of $2^n+1=2^7+1=129$ sequences that satisfy $2^{(n+1)/2}+1$. In particular, the magnitude of the cross correlation is less than or equal to 17.

2.3.2 M-Sequence

A pseudo-noise (PN) sequence is a periodic binary sequence with a noise-like waveform that is usually generated by means of a feedback shift register that is said to be linear when the feedback logic consists entirely of modulo-2 adders . The period of a PN sequence produced by a linear feedback shift register with m flip-flops can not exceed 2^m-1.When the period is exactly 2^m-1, the PN sequence is called a maximal-length-sequence or simply m-sequence

Special Properties

In each period of a m-sequence, the number of 1s is always one more than the number of 0s. This property is called the balance property.

● The autocorrelation function of a m-sequence is periodic and binary-valued. This property is called correlation property..

● There is no general formula for the cross-correlation of two m-sequences, only some rules can be formulated.

3. CORRELATION

It is frequently necessary to be able to quantify the degree of interdependence of one process upon another, or to establish the similarities between one set of data and another. In other words, the correlation between the process or data is sought. Correlation can be defined mathematically and can be quantified. The process of correlation occupies a significant place in signal processing. Application is found in image processing for robotic vision or remote sensing by satellite in which data from different images are compared, in radar and sonar systems for range and position finding in which transmitted and reflected waveforms are compared in detection and identification of signals and noise, in control engineering for observing the effect of inputs on outputs, in the identification of binary code wards in pulse code modulation system using correlation detectors, as an integral part of the ordinary least squares estimation technique, in the computation of the average power in waveforms, in many other fields.

3.1 Correlation Description

Consider two data sequences, each consisting of simultaneously sampled values taken from the two corresponding waveforms, might be compared. If the two waveforms are varied similarly point for point, then a measure of their correlation might be obtained by taking the sum of the products of the corresponding pairs of points. The cross correlation $r_{12}(n)$ between two data sequences $x_1(n)$ and $x_2(n)$ each containing N data might therefore be written as

$$r_{12} = \sum_{n=0}^{N-1} x_1(n) x_2(n)$$ **Eq.1**

This definition of cross-correlation produces a result which depends on the number of the sampling points taken. This is corrected by normalizing the result to the number points by dividing by N.

$$r_{12} = \frac{1}{N} \sum_{n=0}^{N-1} x_1(n) x_2(n)$$ **Eq. 2**

However, this definition needs modification to be useful. In some cases it may indicate zero correlation although the two waveforms are 100% correlated. It is seen that each pair product in the correlation is zero, and hence the correlation is zero, because one of either x_1 of x_2 is always zero.

4. CODE GENERATION

Here, two special type of code generator has been implemented by using Matlab. The generators are:

1. Gold code generator
2. Random noise generator

4.1 GOLD CODE GENERATOR

It is possible to implement different types of gold code generators for different m-sequence combination. Two separate m-sequences, each of which posses different numbers of shift register (flip-flops) and different feedback combinations are possible among them [9].

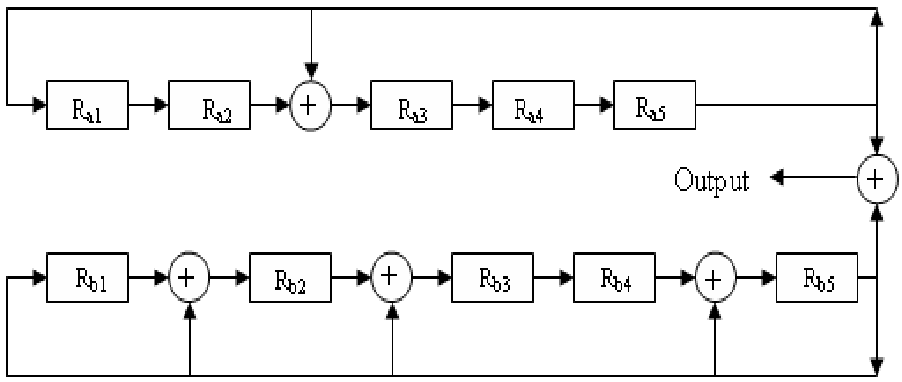

Figure 2. Generation of Gold Sequences of length 31

Here, five flip-flops in each m-sequence are used and their feedback combinations are{2, 5} and {1, 2, 4, 5}. Since each m-sequence have five flip-flops and each of them have 2^5-1=31 bit combinations. So total 31×31 bit combinations are possible. But here worked on only four of them are listed on the Table.1.

Table 1. m-sequence combinations

Serial No.	m-sequence 1 $R_{a1}R_{a2}R_{a3}R_{a4}R_{a5}$	m-sequence 2 $R_{b1}R_{b2}R_{b3}R_{b4}R_{b5}$
1	00001	00001
2	00001	00011
3	00001	00100
4	00001	00010

4.3 Random Noise Generator

A random noise generator is produced which follows the uniform distribution. Then this random noise is applied on both Gold code and Walsh code and finally found out cross correlation between noisy signal and transmitted signal by using Matlab.

5. PERFORMANCE ANALYSIS OF CODES

5.1 Gold Code

Here 31 different codes of 31 bits are generated each using Matlab. The shift register input is 00001 & 00001 (1st case) and its corresponding Gold sequence is 0111000010000110010010111100000.

The auto-correlation curve is shown in figure-3

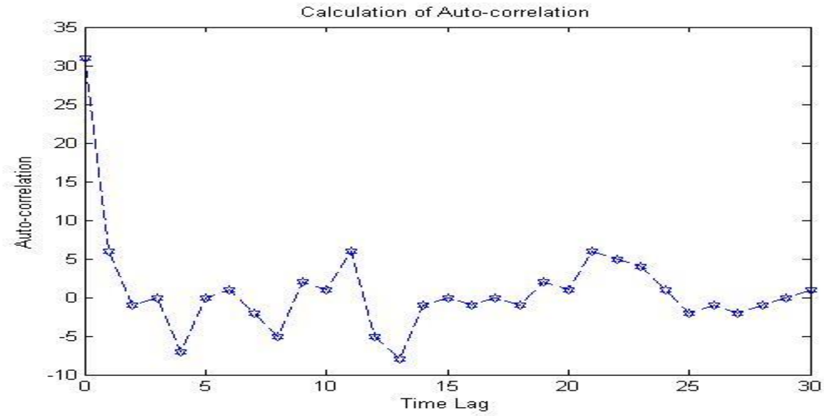

Figure-3: Auto-correlation of Gold sequence for input 00001&00001

The shift register input is 00001 & 00010 (3rd case) and its corresponding Gold sequence is 1110010100000001011111000001000

The auto-correlation curve is shown in figure-4

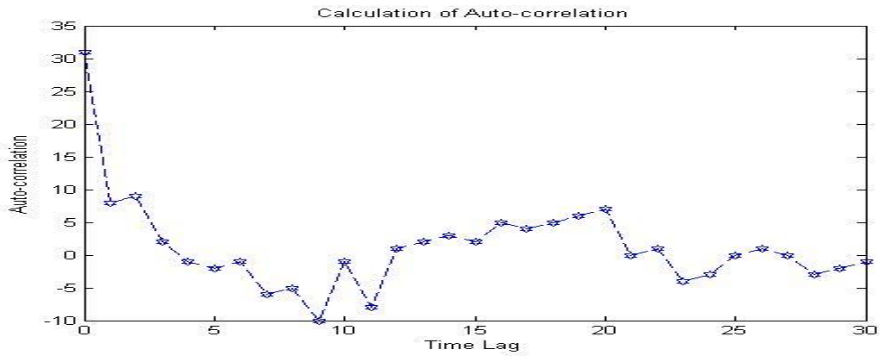

Figure-4: Auto-correlation of Gold sequence for input 00001&00010

It has been shown that the auto-correlation of the code have single pick value at zero time lag. The auto-correlation of the four Gold codes are given in the figure 5.

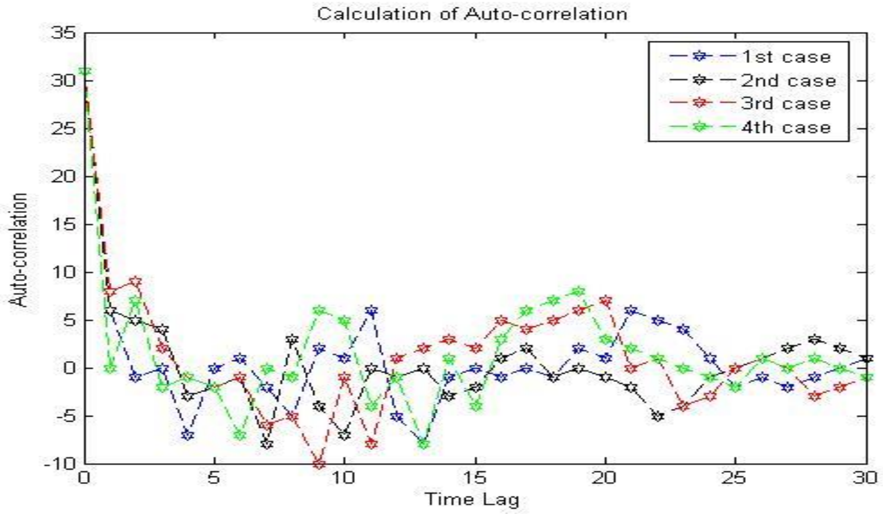

Figure 5. Combined auto-correlation of Gold sequences.

Gold sequences (codes) are constructed from the modulo-2 addition of two maximum length preferred PN sequences.

The shift register input is 00001 & 00001 and its corresponding Gold sequence is 0111000010000110010010111100000 and the shift register input is 00001 & 00011 and its corresponding Gold sequence is 0000001111111011010110010111000 (2nd case) The cross-correlation curve is given in figure-6

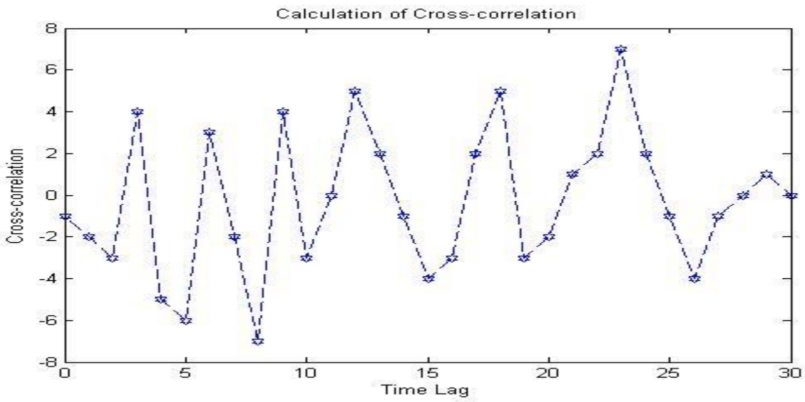

Figure-6: Cross-correlation of Gold sequence for input 00001&00001 and 00001&00011

To examine clearly the correlation graphs are combining together in the figure 6.

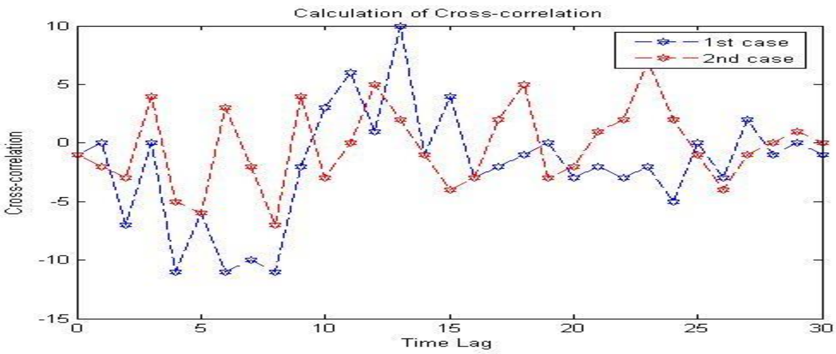

Figure 6. Combined cross-correlation of Gold sequence.

At zero time lag though, curve for data sequence 1 increases from nearly zero but curve for data sequence 2 decrease. Cross-correlation performance of Gold code is not so much better therefore in multi-user environment all codes are not preferred. The values vary between -11 to 10. For first case it is found that cross- correlations among the codes are not good enough. The values vary between -7 to 7.

5.2 Performance of the Codes in Noise

The shift register input is 00001 & 00001 and its corresponding Gold sequence is 0111000010000110010010111100000. Random noise is applied on this sequence and correlation is calculated .The same noise is applied on the Walsh sequence 11110000111100001111000011110000 and correlation is calculated. Combined correlation of original signal and noisy signal for Gold and Walsh code is given to the figure7.

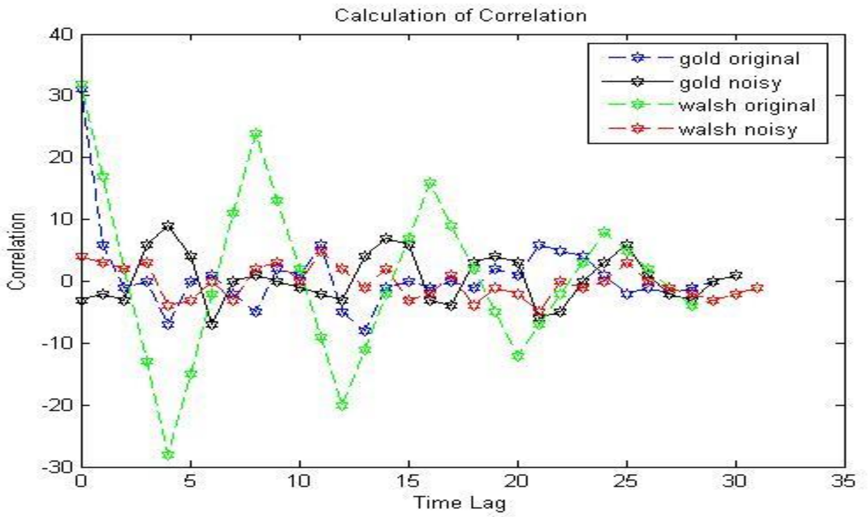

Figure 7. Correlation of Gold code and Walsh code

6. RESULT

By examining the above the figures it has been found that, in case of Gold code original signal, it has a maximum peak at zero time lag but the received signal does not hold this condition exactly. It holds the maximum peak at time lag ten. With the exception of this maximum peak it shows almost same characteristics of the original signal. In the case of Walsh code, the original signal holds constant decreasing slope, but the received signal does not hold this condition. It shows almost opposite characteristics. It differs in a large scale from its original characteristics curve. From the analysis it is observed that, Gold code shows better performance in comparison with Walsh code in noisy environment.

7. CONCLUSION

In this paper it has been shown that Gold code shows better performance in comparison with Walsh code in noisy environment. Here, the performance is analyzed on the basis of the generation of Gold codes of few particular lengths. A process of adding random noise to the generated codes has been found out and at last it is tried to find out how Gold acts on application of random noise. Correlations are tested for the codes, which show better result. Random noise addition was based on uniform distribution; therefore it can be further tested for different distribution Here the code is generated on the basis of only a pair of m-sequences of length five, but it is possible to generate gold codes using different pairs of m-sequences of different lengths which may be further tested.

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