Design of Generalized Discrete Fourier Transform with Non Linear Phase on Real Time System

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Abstract

This paper deals with simulation of various spreading codes on real time system using MATLAB environment. Binary sequences can be used in various spreading code techniques. The spreading codes are used to increase the spread spectrum and proper utilization of the bandwidth. The various spreading codes like M-ary Binary sequences, Gold codes, Walsh codes and Constant modulus function set (GDFT) used in various applications like Discrete Multi-tone, Orthogonal Frequency Division Multiple Access (OFDM), and Code Division Multiple Access. This paper proposes real time system model in which different spreading codes are mixed with voice or speech signal and performance can be analyze in terms of Bit-Error-Rate, Signal-to-Noise ratio and Mean Square Value of auto-correlation and Mean Square Value of Cross-Correlation.

Keywords: *Spread Spectrum, Bandwidth, Generalized Discrete Fourier Transform, Auto-Correlation function, Cross-Cross Correlation function, Bit Interference, PN Sequence, CDMA, Gold Codes, Walsh Codes, Discrete Fourier Transform.*

1. Introduction

Code Division Multiple Access (CDMA) with Direct Sequences spread spectrum is one of the emerging technologies in Wireless communication. CDMA provides better voice quality. In Direct Sequence Spread Spectrum, the main issue is to increase bandwidth spectrum and proper utilization of bandwidth. Increase spectrum will improve the interference and convert the narrowband signal into broadband signal. In Communication, spreading code families like Gold codes, Walsh codes, GDFT have been successfully used for asynchronous communication in DS-CDMA system. Several binary spreading code sets are designed to optimized BER and uses even Cross-Correlation function to recover original data, but it is found that along with even cross-correlation and odd cross-correlation is also very important. Hence Hidenobu Fukumasa, Ryuji Kohno, Hideki Imai proposed a method to design spreading sequences for CDMA. The properties of these sequences are the absolute values of their odd and even correlation function. They discovered a method for Odd cross-correlation by giving a new set of complex pseudo-random noise sequences (PN). This results in lower peaks for both odd and even correlation, which is useful for achieving stable acquisition and increasing CDMA capacity and also reduces co-channel interference and improves BER performance [2][4].

Vaishali Patil, Jaikaran Singh, Mukesh Tiwari simulated mathematical model of Gold Codes, Walsh Codes and GDFT and analyzed the result in terms of BER and SNR. It has been observed that GDFT provides better and efficient correlation function which can be exploited in optimum way of asynchronous CDMA communication system rather than Gold and Walsh codes [1].

T. M. Nazmul Huda, Syed Islam analyzed the performance on the basis of generation of Gold codes and Walsh codes of few particular lengths. A process of adding random noise to the generated codes has been find out and at last it is tried to find out how Gold and Walsh codes act on application of random noise. Correlations are tested for the codes, which show better result. 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. Random noise addition was based on uniform distribution; therefore it can be further tested for different distribution [3].

Ali Akanshu, Handan Agirman-Tosun proposed a mathematical model of Generalized Discrete Fourier Transform (GDFT) to generate spreading code. GDFT can be derived by the definition of Discrete Fourier Transform. GDFT provides a unified theoretical framework where popular constant modulus orthogonal function set including DFT provides foundation to exploits the phase space to improve the correlation property of constant modulus orthogonal set. It is found that GDFT improved correlation over popular DFT, Gold and Walsh as well as Oppermann families, is leading to superior communication performance for the scenario considered in this paper [2][5].

2. Gold Code P-N Sequence

Combining two m-sequences creates Gold codes. These codes are used in asynchronous CDMA systems. Gold sequences are important class of sequences that allow construction of long sequences with three valued auto-correlation function ACF's. Gold sequences are constructed from pairs of preferred m-sequences by modulo-2 addition of two maximal sequences of same length. Gold sequences are useful in non-orthogonal CDMA. Gold sequences have only three cross-correlation peaks, which tend to get less important as the length of the code increases. They also have a single auto-correlation peak at zero, just like ordinary PN sequences. The use of Gold sequences permits the transmission to be asynchronous. The receiver can synchronize using the auto-correlation property of gold sequence.

2.1 Gold Theorem

Let $G_1(x)$ and $G_2(x)$ be a preferred pair of primitive polynomials of degree n whose corresponding shift register generate m-sequences of period 2^n-1 and 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 $n \neq 0 \bmod 4$

Then the shift registers corresponding to the product polynomial G1(X).G2(X) will generate 2^n +1 different sequence, with each sequence having a period of 2^n -1 and the correlation sequence is defined in the next section.

2.2 Correlation Properties of Gold Code Sequence

Consider 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 $2^{(n+1)}/2+1$ =24+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-2.A 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.

3. Walsh Code P-N Sequence

Walsh codes are created out of Hadamard is the matrix type from which Walsh created this codes. Walsh codes have just one outstanding quality. In a family of Walsh codes all codes are orthogonal to each other and are used to create channelization within the 1.25 MHz band. Walsh codes of length 2^n can be defined and generated as different rows of a $2^n \times 2^n$ Hadamard matrix. The following recursive equation can be used to generate higher order Hadamard matrices from lower once.

$$H_{2^n} = \begin{bmatrix} H_{2^{n-1}} & H_{2^{n-1}} \\ H_{2^{n-1}} & H_{2^{n-1}} \end{bmatrix}$$

For example starting with a=1×1 matrix H1=[0], one can define Walsh codes of length 4 as follows

$$H1 = [\,0\,] \qquad H2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

$$H_4 = \begin{bmatrix} H_2 & H_2 \\ H_2 & H_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{bmatrix} \rightarrow$$

$$\begin{Bmatrix} W0 = [-1-1\ -1-1] \\ W1 = [-1+1\ -1+1] \\ W2 = [-1\ -1+1+1] \\ W3 = [-1\ +1+1\ -1] \end{Bmatrix}$$

4. Design Model Generalized Discrete Fourier Transform

4.1 Mathematical Preliminaries and Discrete Fourier Transform

In this paper we are using GDFT framework to generate spreading codes. The complex roots of unity are widely proposed as complex spreading codes. All codes of such a set are placed on the unit circle of the complex z plane [2].

An N^{th} root of unity is a complex number z satisfying the polynomial equation.

$$z^N - 1 = 0 \qquad N \in \{1, 2, 3\} \qquad (1)$$

All primitive Nth roots of unity satisfy the unique summation property of a geometric series expressed as follows:

$$\sum_{n=0}^{N-1} (z_p)^n = \frac{(z_p)^n - 1}{z_p - 1} = \begin{Bmatrix} 1, N = 1 \\ 0, N > 1 \end{Bmatrix} \forall p \qquad (2)$$

Now define a periodic, constant modulus complex sequence $\{e_r(n)\}$ as the rth power of the first primitive Nth roots of unity

$$e_r(n) \triangleq (z_1^r) = e^{j(2\pi r/N)n} \quad (3)$$

Where n = 0,1,2,3,…N-1 and r = 0,1,2,..N-1 The complex sequence III over a finite discrete time interval in a geometric series is expressed as follows [1][2]

$$\frac{1}{N}\sum_{n=0}^{N-1} e_r(n) = \frac{1}{N}\sum_{n=0}^{N-1}(z_1^r)^n = \frac{1}{N}\sum_{n=0}^{N-1} e^{j(2\pi r/N)n} \quad (4)$$

$$= \left\{ \begin{matrix} 1, & r = mN \\ 0, & r \neq mN \\ & m = integer \end{matrix} \right\}$$

Then from equation (4) DFT on set $\{e_r(n)\}$ satisfying orthonormality conditions [2]

$$\langle e_k(n), e_l^*(n) \rangle = \frac{1}{N}\sum_{n=0}^{N-1} e^{j(2\pi/N)(k-l)n} \quad (5)$$

$$\left\{ \begin{matrix} 1, & r = k - l = mN \\ 0, & r = k - l \neq mN \\ & m = integer \end{matrix} \right\}$$

The Notation (*) represents complex conjugates function of a function.

4.2 Generalized Discrete Fourier Transform

Generalize (4) by writing the phase difference of two function $\varphi_{kl}(n) = \varphi_k(n) - \varphi_l(n) = r \ \forall \ n$ and expressing constant modulus function set as follows [2],

$$\frac{1}{N}\sum_{n=0}^{N-1} e^{j(2\pi\varphi k(n)/N)n}\, e^{-j(2\pi\varphi k(n)/N)n} \quad (6)$$

Hence the basic function of a new set are defined as follows

$e_k(n) \triangleq e^{j(2\pi/N)\varphi_{k(n)}n}$ where k = 0,1,2,……., N-1

This is orthogonal function set as the Generalized Discrete Fourier Transform (GDFT).

4.3 Design Methodology of Generalized Discrete Fourier Transform

DFT matrix of N $\times N$ expressed as

$$A_{DFT} = \left[A_{DFT_{(k,n)}}\right]$$

$$A_{DFT} = \left[e^{j(2\pi/N)kn}\right] \quad k, n = 0, 1, 2, N\text{-}1 \quad (7)$$

Now, we will define a GDFT by relaxing the linear phase property of DFT without compromising the orthogonality. This is a marked departure from the traditional Fourier analysis including DFT where any set regardless continuous or discrete in time has its linear phase functions. Hence, we express the square GDFT matrix as a product of the three orthogonal matrices as follows [2]

$$\begin{aligned} A_{GDFT} &= G_1 A_{DFT} G_2 \\ A_{GDFT} A_{GDFT}^{-1} &= I \\ A^{-1}{}_{GDFT} &= A_{GDFT}^{*T} \\ G_1 G_1^{*T} = I \quad & G_2 G_2^{*T} = I \end{aligned} \quad (8)$$

Where G1 and G2 are constant modulus diagonal matrices and written as [2]

$$G_1(k,n) = \left\{ \begin{matrix} e^{j\theta_{kk}}, & k = n \\ 0, & k \neq n \\ & k, n = 0,1, \ldots N \end{matrix} \right\}$$

and

$$G_1(k,n) = \left\{ \begin{matrix} e^{j\gamma_{nn}}, & k = n \\ 0, & k \neq n \\ & k, n = 0,1, \ldots N \end{matrix} \right\} \quad (9)$$

4.4 Performance Matrices of Generalized Discrete Fourier Transform

In order to compare performance of code families, several objective performance metrics were used in the literature. All the metrics used in this study depend on a periodic correlation functions (ACF) of the spreading code set. The ACF metric is defined for the complex sequences $\{e_k(n)\}$ and $\{e_l(n)\}$ [8].

$$d_{k,l}(m) = \left\{ \begin{matrix} \frac{1}{N}\sum_{n=0}^{N-1-m} e_k(n) e_l^*(n+m), 0 < m \leq N-1 \\ \frac{1}{N}\sum_{n=0}^{N-1+m} e_k(n-m) e_l^*(n), \quad 1-N < m \leq 0 \\ 0, \quad |m| \geq N \end{matrix} \right\} \quad (10)$$

By using this matrix the correlation matrices like Auto-correlation and Cross-correlation has been generated and result is been analyzed on mathematical model based.

5. Proposed System

The proposed work is the MATLAB simulation of Gold, Walsh and GDFT on a real time system model. Real time system model architecture designed as below

Authors' Names and Addresses: The authors' names

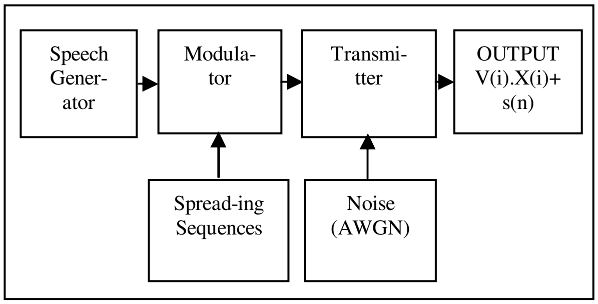

Fig. 1 Real Time System Model at Transmitter

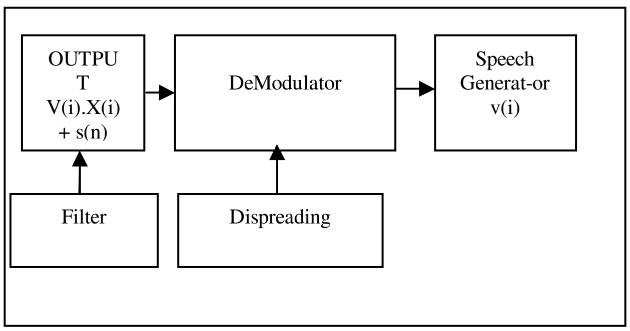

Fig. 2 Real Time System Model at Receiver

In this paper Real Time System work on input voice speech signal V(i) of different person which is digital in nature and mixed with the various spreading codes. The performance of Real Time System can be observed on BER, SNR and Mean Square value. Real Time System approach works on various spreading coding techniques and mentioned in below section.

5.1 Design of Real Time System Model with Gold Code Sequence (RTSMGC)

RTSMGC model uses Gold codes for spreading, in this input speech i.e. voice signal V(i) is mixed with Gold codes PN sequence as spreading X(t) and passes through the Real Time System Model discussed in above section. This system model can be simulated in MATLAB. The main aim to recover original signal after performing dispreading at the receiver. It is found that we are not getting the exact 100% of original data, it can have noise.

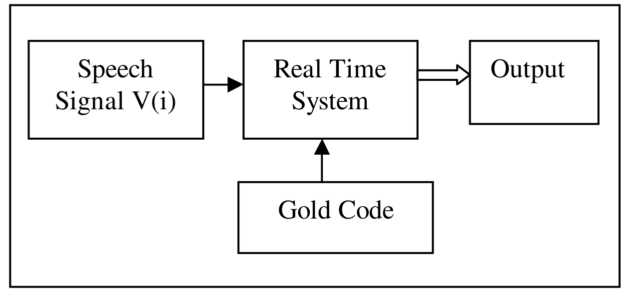

Fig. 3 Design of Gold Code on RTS

Above model generate output data and compared with original data. The result can be analyzed in terms of Signal to Noise Ratio and Bit Error Rate. As signal to noise ratio increases the Bit Error Rate is also increases.

5.2 Design of Real Time System Model with Walsh Code Sequence (RTSMWC)

RTSMWC model uses Walsh codes for spreading. The design model of Walsh codes described in following diagram. Input voice signal V(i) is mixed with Walsh codes PN sequence as spreading signal Y(t) and passes through the Real Time System Model. Finally result analyzed on SNR and BER and Mean Square Value parameter.

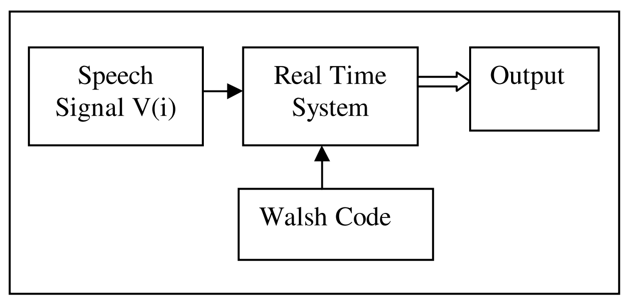

Fig. 4 Design of Walsh Code on RTS

5.3 Design of Real Time System Model with Generalized Discrete Fourier Transform

A constant modulus function set used to design spreading code name as Generalized Discrete Fourier Transform GDFT. Derivation of GDFT already discussed in above section. Literature reviews that GDFT is best spreading code to spread spectrum technique. In the proposed plan we are developing Real Time Model which uses the GDFT spreading codes. The result of this system directly view on real time model on the basis of that we will proposed the best and efficient spreading codes for DSSS techniques.

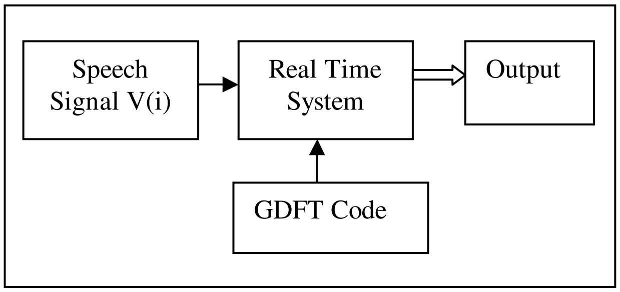

Fig. 5 Design of GDFT Code on RTS

6. Conclusion

In this paper we have discussed various spreading code techniques like Binary, Gold, Walsh and GDFT. We are applying these techniques directly on real time system. This model performs spectral analysis of speech signal to determine whether it contains stress or not. In this proposed model speech samples of different persons will be recording at different time interval time. On SNR and BER and Mean Square Value parameters we compare the PN sequences Gold, Walsh and GDFT. On the basis of comparison we state the better PN sequence used in spreading and can be used in CDMA.

References

[1] Vaishali Patil, Jaikaran Singh, Mukesh Tiwari "Simulation of GDFT for CDMA", MPGI National Muti-Conference 2012.

[2] Ali N. Akanshu, Handan Agirman "Generalized Discrete Fourier Transform", IEEE Transaction on Signal Processing, vol 58, N0.9, Septmber 2010.

[3] T. M. Nazmul Huda, Syed Islam "Correlation Analysis of the Gold Codes and Walsh Codes in CDMA Technology", IEEE, 2009

[4] Hidenobu Fukumasa , Ryuji Kohno, and Hideki Imai "Design of Pseudo Random Noise Sequences with Good Odd and Even Correlation Properties" IEEE Second International Symposius on Spread Sprectrum tech. and Application, Japan Nov 29 Dec 2, 1992.

[5] Richard Haddad Ali Akansu "A new Orthogonal Transform for signal Coding".

[6] Richard Haddad Ali Akansu "A new Orthogonal Transform for signal Coding".

[7] Ian Oppermann "Orthogonal Complex Valued Spreading Sequences with a wide Range of Correlation Properties", IEEE transaction on communication Vol. 45, N0 11, Nov 1997.

[8] A. K. S. Al- Bayati and S. Prasad "Modified constant modulus algorithm for blind DS/CDMA", Electronics Lett, 1999.

[9] Rochlani, Yogesh R., and A. R. Itkikar. "Integrating Heterogeneous Data Sources Using XML Mediator." International journal of computer science and network, Vol 3,2012.

[10] Ian Oppermann and B.S. Vucetic "Complex Valued Spreading Sequences with a wide Range of Correlation Properties", IEEE transaction on communication Vol. 45,pp. 365-375 N0 11, March

[11] Cenk Kose, Keith M. Chugg and Thomos R. Halford "Constant Modulus Orthogonal Frequency Division Multiplexing", 2010 IEEE Military communication conferenece.

[12] Intitive Guide to principles of communications www.complextoreal.co Copy Right 2002 Charan Langton.

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