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Review Article

Comparative Analysis of the BER Performance of WCDMA Using Different Spreading Code Generator

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Abstract: In recent times the Wideband Code Division Multiple Access (WCDMA) is one of the most used. This is because it provides higher data rates in mobile communication and it provides the users with many multimedia applications such as video streams and high resolution pictures. In other to enhance the performance of the technology a suitable modulation technique and error correcting technique is implemented.in this paper I have done performance analysis of different spread spectrum sequence with the Quadrature Phase Shift Keying (QPSK) modulation technique when the system is subjected to multipath Rayleigh fading and Additive White Gaussian Noise (AWGN). The research has been done using MATLAB for simulation and evaluation of the bit error rate for the WCDMA system models.

Keywords: WCDMA, QPSK, PN Code, Gold Code, Walsh Code, GMSK, Rayleigh Fading

1. Introduction

Current generation systems are designed to support multimedia applications. For this reason, the WCDMA supports higher capacity and has better limiting features of multipath propagating effects. These third generation systems provide services with high data rates for both public and private networks. WCDMA uses noise-like broadband frequency spectrum where it has high resistance to multipath fading whereas this was not present in the conventional narrowband signal of second generation (2G) communication system [1].

In 2G communication systems, Gaussian Minimum Shift Keying (GMSK) modulation scheme is widely used in GSM communication. This modulation technique can only transmit 1 bit per symbol, so it is not suitable for the next generation communications systems. It is therefore important to study a new modulation technique that could deliver higher data rate effectively in a multipath fading channel [9].

The implementation of high data rate modulation techniques that have good bandwidth efficiency in WCDMA cellular communications requires perfect modulators, demodulators, filters and transmission paths that are difficult to achieve in practical radio environment. Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily produced as the number of users is increased and the mobile terminal is subjected to mobility. Thus, it has driven many researches into the application of higher order modulations [2, 8, 10].

This paper focuses on the performance measurement of high data rate modulation schemes in channels which are subjected to Multipath Rayleigh Fading and Additive White Gaussian Noise (AWGN). AWGN is the effect of thermal noise produced by thermal motion of electron in all dissipative electrical components i.e. resistors, wires and so on [3]. Mathematically, thermal noise is described by a zero mean Gaussian random process where the random signal is a sum of Gaussian noise random variable and a dc signal which is shown in the equation

$$Z = a + n \quad (1)$$

And the Probability Distribution Function (pdf) for Gaussian noise is shown as follows

$$P(z) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{z-a}{\sigma}\right)^2\right] \quad (2)$$

The effect can cause fluctuations in the received signals amplitude, phase and angle of arrival, giving rise to terminology multipath fading.

The performance of a WCDMA system is better improved by using spreading codes. The different spreading codes with different spreading length are used to support high bit rate and mitigate the effect of inter-symbol interference (ISI) and narrowband interference in WCDMA. The main property of the spreading code is they need to be orthogonal to each other. Some of these spreading codes are Hammard codes, PN sequence, Gold sequence and Walsh codes.

The pseudorandom (PN) sequence is deterministically generated; however, it is almost like random sequences to an observer. The PN sequence is usually implemented by using sequential logic circuits [4].

Gold sequence is another type of sequence used in WCDMA techniques [5]. Gold codes are obtained from a modulo-2 addition of two maximum length sequences. Gold sequences are generated on the basis of preferred pair m-sequences.The gold sequence has inter-code interference.

Walsh code is used as spreading code with less spreading factor. Walsh codes are used in direct sequence and frequency hopping spread spectrum (such as IS95, cdma2000 etc.). Walsh codes are orthogonal codes. They are generated by using Hammard matrix. From the corresponding Hammard matrix the Walsh codes are given by rows [6].

QPSK is a type of M-ary PSK modulation technique where M=4, it transmits 2 bits per symbol. The phase carrier is divided into four equally spaced values which are 0, $\pi/2$, π and $3\pi/2$ each value of the phase is represents a pair of message bits. The basic signal of QPSK is expressed as

$$S_{QPSK}(t) = \left\{\sqrt{E_s}\cos\left[(i-1)\frac{\pi}{2}\right]\Phi_1(t) - \sqrt{E_S}\sin\left[(i-1)\frac{\pi}{2}\right]\Phi_2(t)\right\}$$

$$i=1,2,3,4 \quad (3)$$

2. Related Works

[1] in their paper compared modulation technique using M-ary Quadrature Amplitude Modulation (QAM) and Quadrature Phase Shift Keying (QPSK) are considered in Wideband Code Division Multiple Access (WCDMA) system. The system was subjected to Additive White Gaussian Noise (AWGN) and multipath Rayleigh fading.

[2] in their paper studied the wideband code division multiple access (WCDMA) downlink over various narrowband and wideband channels. Implementation issues and performance were discussed; particularly when space time transmit diversity (STTD) is employed.

[5] in their paper designed a system to compare the various modulation techniques of Binary Phase Shift Keying (BPSK) and other Phase Shift Keying modulation techniques. Their comparison was done by finding the Bit Error Rate of each of the modulation techniques.

[6] compared the QPSK and QAM modulation techniques used in WCDMA in other to improve the performance of the system. At the end of the research, QPSK was seen to be a more reliable modulation technique.

[7] performed analysis of WCDMA using different spreading codes such as Walsh codes, gold codes, etc. this research was carried out in the presence of Rayleigh fading with AWGN. From their simulation results, it was seen that BER of WCDMA can be improved drastically by using Walsh code.

[4] paper describes an efficient way of implementing the hardware of a sign Walsh transform. Such a non-linear transform converts binary/ternary vectors into the spectral domain and is important in many signal processing applications including CDMA coding and the analysis of logic design. The approach used is based on fixed butterfly diagrams that are easily implemented in hardware.

3. Methodology

The MATLAB simulation tool was used to develop and simulate the model as shown in figure 1. The system was developed using blocks from the communication block set found in the Simulink library. All parameters for each block were set on the block properties dialog box.

Various spreading sequences are considered such as PN, Gold and Walsh code in the presence of Rayleigh channel and AWGN.

The modulation technique used is the QPSK modulation at the transmitter whose output is a baseband representation of the modulated signal. At the receiver, the QPSK demodulator is used to demodulate the modulated signal.

At the transmitter, a raised cosine filter is used to up sample the input signal and at the receiver another raised cosine filter is used to change the overall response of the signal.

There are different fading effects and Rayleigh fading represents the worst case of multipath fading. It represents small scale fading due to small changes in position with respect to time that is Doppler Effect. On the other hand, AWGN represents thermal noise generated by electrical instruments.

The following steps were taken to analyze the different spreading code models as shown in fig. 1.

- Simulation was run in intervals of 50 Matlab seconds.
- Records were taken for error rate and no of errors for the Walsh code, PN code and the Gold code models respectively.
- In each model, the option 'stop simulation' was disabled to allow for runtime in the Bit Error Rate display

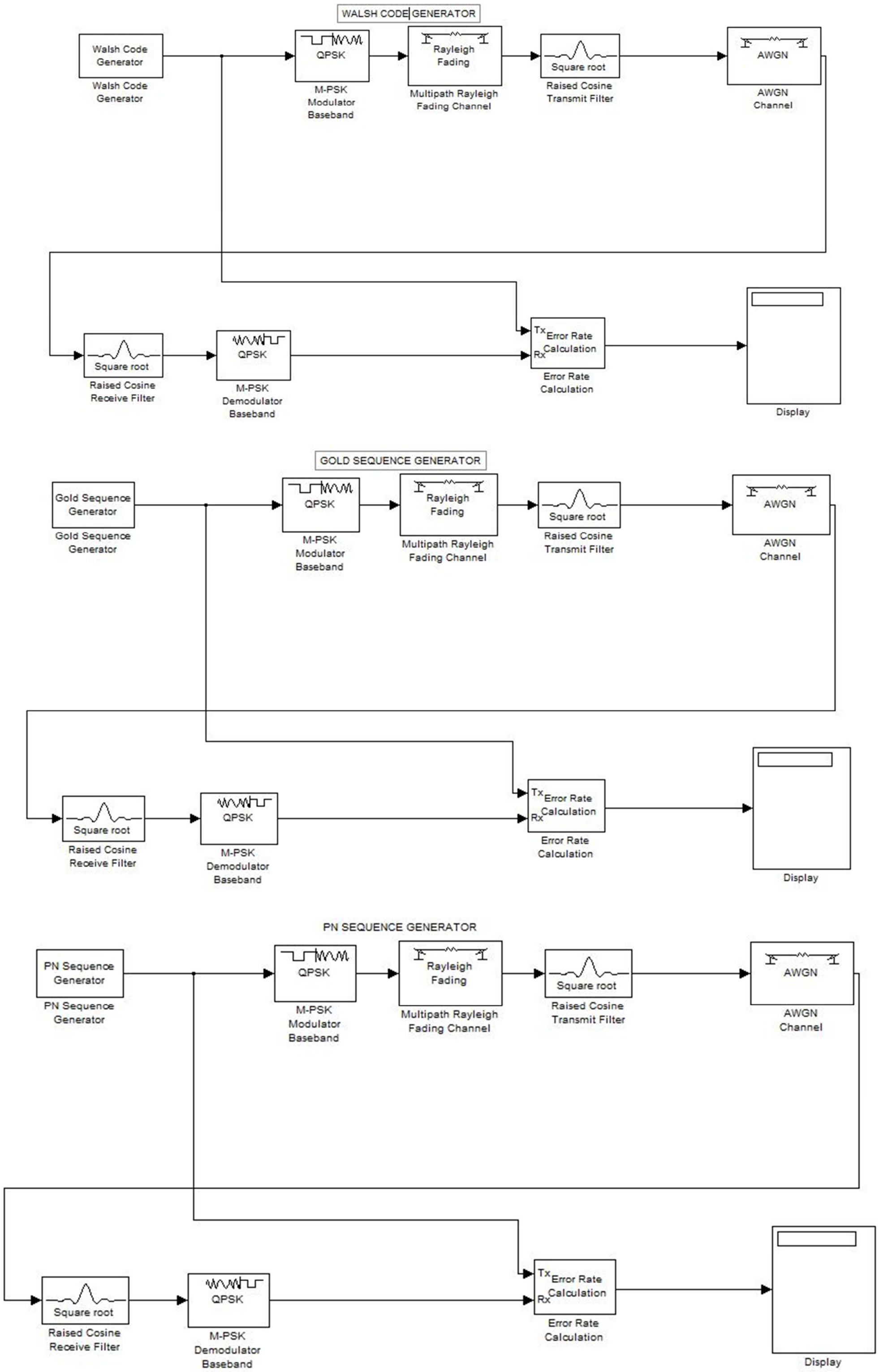

Fig. 1. Comparative models for the different spreading codes.

4. Results and Discussions

Based on the data generated by the MATLAB simulation for the WCDMA model using different spread spectrum generators. The simulation was run in intervals of 50 MATLAB seconds. The BER (Bit Error Rate) for the Walsh code is seen to be higher than that of the PN code and the Gold code over the same period. These results are seen in the tables.

Table 1. *BER result for Walsh code, PN code and Gold spreading sequence model at increasing simulation time.*

Bit Error Rate			
RUNTIME	WALSH CODE	PN CODE	GOLD CODE
50	0.9216	0.8431	0.8431
100	0.901	0.8119	0.8317
150	0.9139	0.8212	0.8477
200	0.9303	0.8458	0.8607
250	0.9283	0.8247	0.8606
300	0.9236	0.8339	0.8571
350	0.9202	0.8405	0.8632
400	0.9202	0.8404	0.8678
450	0.9113	0.8337	0.8714
500	0.9082	0.8263	0.8483
550	0.9074	0.8258	0.8457
600	0.9018	0.822	0.8353
650	0.9017	0.8187	0.8341
700	0.893	0.8188	0.8317
750	0.8802	0.8109	0.8229
800	0.8702	0.8065	0.8152
850	0.8578	0.8049	0.812
900	0.8457	0.798	0.808
950	0.837	0.7918	0.795
1000	0.8212	0.7842	0.7829

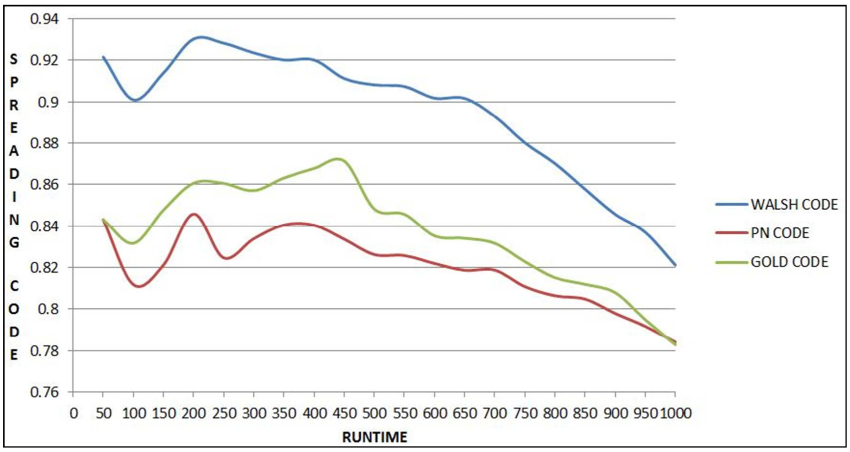

Fig. 2. *Overall Comparative Bit Error Rate for the Different Spreading Codes.*

Table 2. *Number of errors generated from the different spreading codes at different simulation time.*

No. of Errors			
RUNTIME	WALSH CODE	PN CODE	GOLD CODE
50	47	43	43
100	91	82	84
150	138	124	128
200	187	170	173
250	233	207	216
300	278	251	258
350	323	295	303
400	369	337	348
450	411	376	393
500	455	414	425
550	500	455	466
600	542	494	502
650	587	533	543
700	626	574	583
750	661	609	618
800	697	646	653
850	730	685	691
900	762	719	728
950	796	753	756
1000	822	785	784

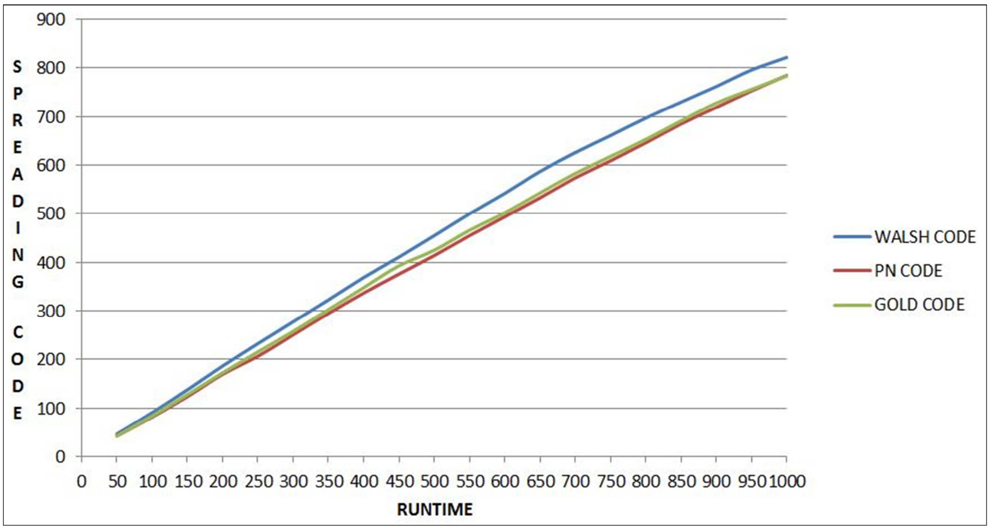

Fig. 3. *Overall Comparative Number of Errors for the Different Spreading Codes.*

The simulation is successfully done using QPSK modulation technique and the desired BER graphs for the simulations are obtained. The BER performance of the Walsh code generator is better than that of the PN code and gold code generators.

5. Conclusion

In this paper, the comparative analysis of the Bit Error Rate performance of Wideband Code Division Multiple Access using different spreading codes has been achieved. It includes the design of the model using Matlab/Simulink. It is that the Walsh Spreading code has a higher Bit Error rate than that of the PN code and Gold code in the presence of multipath fading with AWGN in the transmission channel.

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