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PERFORMANCE ANALYSIS OF DOWNLINK POWER CONTROL IN WCDMA SYSTEM

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Abstract: WCDMA (Wideband Code Division Multiple Access) plays the best competitive role in the present world. The demand for high speed mobile wireless communication is rapidly growing. WCDMA is a promising technique for achieving the high data capacity and spectral efficiency requirements for wireless communication system of the near future. Power control is important aspects of WCDMA system. The main sources of errors in the received powers arise from inaccurate SIR estimation, signaling errors and delays in the power control loop. The performance is analyzed by plotting the graphs of BER against the signal to noise ratio SNR. This project is also concerned with how well WCDMA performs when signal is transmitted over an Additive White Gaussian Noise (AWGN) channel or both AWGN channel and Rayleigh fading channels. The result of the simulation is shown by plotting the Bit Error Rate (BER) versus Signal to Noise Ratio (SNR), which provides the estimation about the system performance.

Index terms −Wideband CDMA (WCDMA), SIR, Fast Power Control, Channelized Code, Soft Handover

I. INTRODUCTION

The goal for the third generation of mobile communications system is to seamlessly provide a wide variety of communication services to anybody, anywhere, anytime [1]. The technology needed to tackle the challenges to make these services available is popularly known as the Third Generation (3G) Cellular Systems. Third generation systems mark a significant leap, both in applications and capacity, from the current second generation standards. Whereas the current digital mobile phone systems are optimized for voice communications, 3G communicators are oriented towards multimedia message capability.

Third generation WCDMA system supports of high data rate transmission: 384 kbps with wide area coverage, 2 Mbps with local coverage. It also supports high service flexibility and multiple parallel variable rate services on each connection. WCDMA supports two basic mode of operation. They are Frequency Division Duplex (FDD) and Time Division Duplex (TDD). Power control compensate for interference in WCDMA system. It also reduce the near far problem effects. The purpose of this project is to simulate WCDMA system and analysis the performance of the system.

II. PRINCIPLE OF WCDMA

WCDMA is a wideband Direct-Sequence Code Division Multiple Access (DS-CDMA) system, i.e. user information bits are spread over a wide bandwidth by multiplying the user data bits with quasi-random bits (called chips) obtained from CDMA spreading codes [2],[8]. In order to support very high data bit rates (up to 2Mbps), the use of a variable spreading factor and multi code connections is supported. The basic operations is spreading and despreading for a DS-CDMA system. User data is here assumed to be a BPSK-modulated bit sequence of rate R , the user data bits consider the values of S1 (user1 data). The spreading operation is the multiplication of each user data bit with a sequence of 8 code bits, called chips. We assume this also for the BPSK spreading modulation. During de-spreading, we multiplied the spread user data/chip sequence, bit duration by bit duration, with the very same 8 code chips as we used during the spreading of these bits.

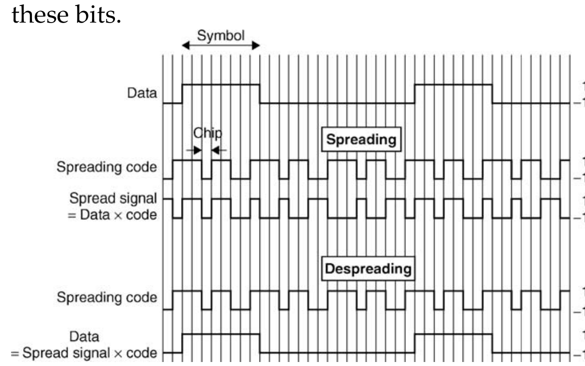
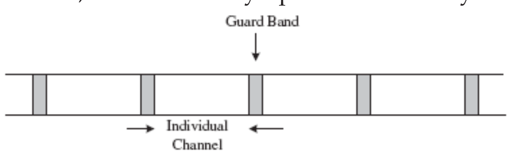


Figure 1: Spreading and de-spreading in DS-CDMA

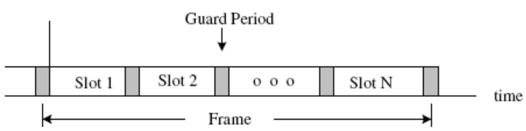
It is important to understand that spreading/de-spreading by itself does not provide any signal enhancement for wireless applications [1]. The result of multiplying the interfering signal with the own code and integrating the resulting products leads to interfering signal values lingering around 0.

Multiple Access Schemes: UMTS W-CDMA FDD is a direct-sequence CDMA system with a nominal bandwidth of 5 MHz The second system, UMTS W-CDMA TDD, also uses CDMA with a bandwidth of 5 MHz, but now the frequency band is time shared in both directions—one half of the time, it is used for transmission in the forward direction and the other half of the time in the reverse direction. Cdma2000 is a multicarrier, direct-sequence CDMA FDD system.

Frequency Division Multiple Access (FDMA): In this scheme, the available spectrum is divided into a number of smaller bands of equal bandwidths, each of which is assigned to a different user for the duration of a call. A guard band must be provided between any two adjacent bands or channels as they are called, for satisfactory operation of the system.



Time Division Multiple Access (TDMA): In TDMA information from multiple users is sent out in fixed size frames, each consisting of a number of equal time slots. Any given user may be assigned one or more of these slots and is allowed to transmit only during the allocated slot(s) in each frame using the entire bandwidth of the channel. A guard period must be provided between any two adjacent time slots so that transmissions from different users do not overlap.



Code Division Multiple Access (CDMA): Code division multiple access (CDMA) is a channel access method utilized by various radio communication technologies. One of the basic concepts in data communication is the idea of allowing several transmitters to send information simultaneously over a single communication channel. This allows several users to share a bandwidth of different frequencies. This concept is called multiplexing [7]. CDMA employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel.

Direct-Spread CDMA Principles: PN codes have some unique properties. One of them is that any physical channel or user application, when spread by a PN code at the transmitter, can be uniquely identified at the receiver by multiplying the received baseband signal with a phase coherent copy of that PN code [6] [8].

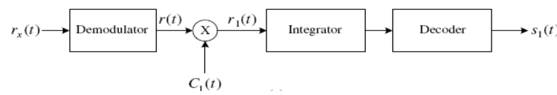


Figure2: A simplified CDMA receiver

The received signal from multiple users is first demodulated. The output of the demodulator, which is a baseband signal, is multiplied by the PN code assigned to user1. The resulting output is applied to the input of an integrator where it is integrated over each symbol period. The decoder reads the output of the integrator and decodes it into binary data, following certain rules.

Assume that the data stream from any user is represented by $S_i(t)$ and its associated PN code by $C_i(t)$. The output at the transmitter after spreading is $v_i(t) = S_i(t)*C_i(t)$. The signal level of $S_i(t)$ or $C_i(t)$ level is either +1 or -1, with +1 representing binary 0 and -1 a binary 1.

$$r(t) = \sum_{i=0}^{N} S_i(t) * C_i(t)$$

where N is the number of users in the system. Now if $r(t)$ is multiplied by a copy of the PN code $C_1(t)$ of user1, the resulting output is given by

$$r_1(t) = C_1(t) * r(t) = C_1(t) * \sum_{i=0}^{N} S_i(t) * C_i(t)$$

$$= S_1(t) * C_1(t) * C_1(t) + S_2(t) * C_2(t) * C_1(t) + \cdots$$

Because the cross-correlation between $C_1(t)$ and $C_2(t)$ is very small, the second term appears as noise so that when it is integrated over a symbol period, the output of the integrator due to this term is virtually zero[8]. However, the output of the integrator due to the first term, when averaged over a symbol period, is $S_1(t)$ because

$$C_1(t) * C_1(t) = 1 .$$

Capacity of a CDMA System: Consider a single cell CDMA system where a number of mobiles are simultaneously transmitting at the same frequency. Here, each mobile is assigned a unique PN code sequence. Let

P =carrier power
E_b =Energy per bit
B_c = spread spectrum signal bandwidth
F_{data} = information bit rate
I = power due to interference
N_0 = noise power per bit

Then,
$$E_b = \frac{P}{f_{data}}$$

$$E_b/N_0 = \frac{P}{N_0 f_{data}}$$

$$N_0 = \frac{I}{B_c}$$

So, $$\frac{E_b}{N_0} = \frac{P}{I} * \frac{B_c}{f_{data}} = \frac{P}{I} * G_p$$

Here G_p is the RF bandwidth divided by the information bit rate. In the CDMA system being discussed here, the signal is Quadrature Phase Shift Keying (QPSK)-modulated, where the RF bandwidth is approximately equal to the chip rate. $B_c = f_{chip}$ and in that case $G_c = f_{chip}/f_{data}$ is called the *process gain*. If there are *N* transmitters, all transmitting at the same power and using the same chip rate, then

$$I = (N - 1) * P$$

So, using equation (1),

$$\frac{I}{P} = \frac{(N-1) * P}{P} = N - 1 = \frac{G_p}{E_b/N_0}$$

Or

$$N = 1 + \frac{G_p}{E_b/N_0} \approx \frac{G_p}{E_b/N_0}$$

For large values of N

III. POWER CONTROL

Power control is an important aspect of WCDMA system. Some of these issues were not present in the existing second generation CDMA and GSM system so, that are new in the third generation system and therefore requirement special attention. In this Section fast power control is presented and next section analyzed the outer loop power control [2] [6]. Outer loop power control sets the target SIR for fast power control so that the desired quality is provided. Two special aspects of fast power control are presented as following:

1. The relationship between fast power control and diversity.
2. Fast power control in soft handover.

The importance of diversity is analyzed together with fast power control. At low UE speed the fast power control can compensate for the fading of the channel and keep the received power level fairly constant. The main sources of errors in the received powers arise from inaccurate SIR estimation, signaling errors and delays in the power control loop. In the simulations the received and transmitted powers are collected slot by slot. With ideal power control the power rise would be 2.3 dB. At low UE speeds the simulated power rise values are close to the theoretical value of 2.3 dB, indicating that fast power control works efficiently in compensating the fading. At high UE speeds (>100 km/h) there is only very little power rise since the fast power control cannot compensate for the fading.

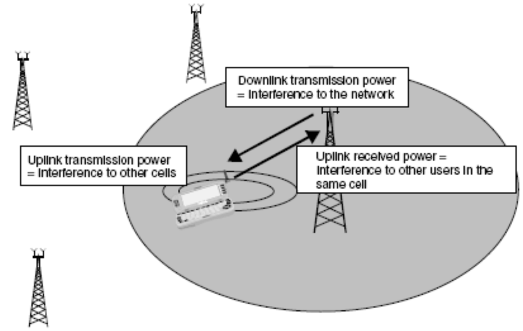


Figure 3: Effect of received and transmission powers on interference levels.

In the uplink, the transmission powers determined the amount of interference to the adjacent cells, and the received powers determined the amount of interference to other UEs in the same cell. If, for example, there were only one WCDMA cell in one area, the uplink capacity of this cell would be maximised by minimising the required received power, and the power rise would not affect the uplink capacity [5].

Power control is an important feature of a WCDMA system. Its main objective is to ensure a satisfactory signal-to-interference ratio at the receiver for all links in the system [6] [9]. In UMTS, different power control procedures are used for uplink and downlink physical channels [10].

Open Loop Power Control: This is the process where UE sets its transmitter power output to any specific level. The open loop power control tolerance is -9 dB under normal conditions and -12 dB under extreme conditions.

Closed loop power Control: In the uplink accordance with TPC (Received in the downlink) and when the UE (MS1, MS2) send to Node BS the interference signal (SIR) and node BS compare SIR with the target SIR. UE adjust the output power. UE can change the out power to 1, 2 or 3 dB [2] [6].

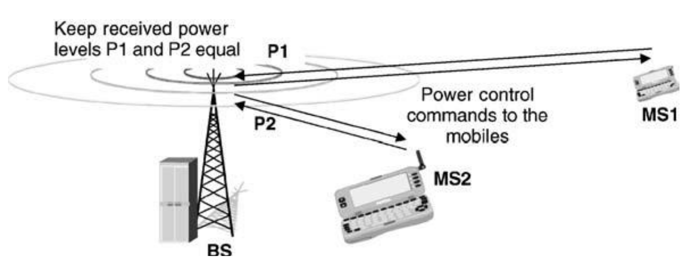


Figure 4: Closed loop power control.

Outer Loop Power Control: The outer loop power control is needed to keep the quality of communication at the required level by setting the target for the fast power control. The outer loop aims are providing the required quality: no worse, no better. Too high quality would be wasted capacity. The outer loop is needed in both uplink and downlink because there is fast power control in both uplink and downlink. The uplink outer loop is located in RNC and the downlink outer loop is located in UE.

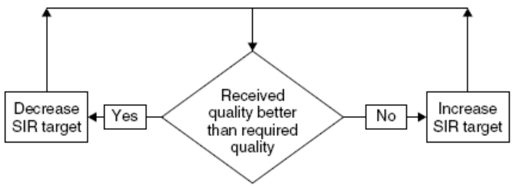


Figure 5: General outer loop power control algorithm

Power Control of Soft Handover: Fast power control in soft handover has two main issues which are different from single link case: power drifting in the Node B powers in the downlink and detection of the uplink power control commands in the UE [2]. These are illustrated in figure 6.

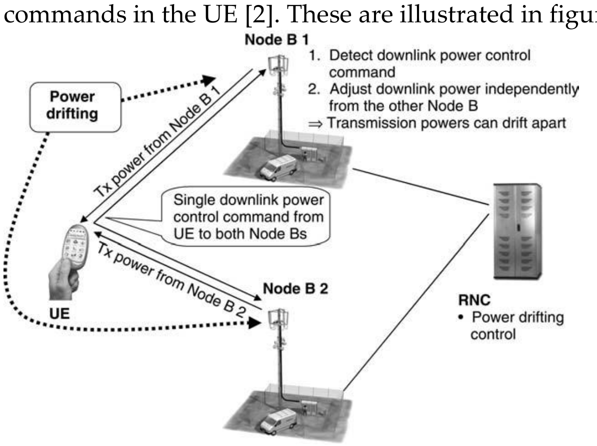


Figure 6: Downlink power drifting in soft handover.

Downlink Channel: The spreading of downlink channel is slightly different from uplink channel. Incoming symbols on all downlink channels except AICH may be +1, -1 or 0. Symbol 0 corresponds to the transmission is to be discontinued [2] [3].

Channelized Code: The channelization codes are mutually orthogonal and are obtained from an Nth order, orthogonal Walsh, or Hadamard matrix:

$$H_N=[h_{ij}] , \qquad i,j=0,1,2,\ldots\ldots\ldots,N-1$$

Where h_{ij} is either +1 or -1. This matrix is called orthogonal because the product of any two inner rows is 0:

$$\sum_{k=0}^{N} h_{ij} = 0 \quad \text{for } i \neq j$$

IV .SIMULATION RESULTS & DISCUSSION

For performing simulations, simulation was developed under MATLAB 7.0 environment. This work is mainly dependent on the performance of the system when signal passed through the downlink channel and power control of the system. For simulation, we have taken four scenarios for AWGN channel and Rayleigh fading channel in WCDMA network. In this simulation we considered users=2, Number of sub carrier n=4, Numbers of bit N and M, Walsh code, fours power taps. We used BPSK modulation and QPSK modulation.

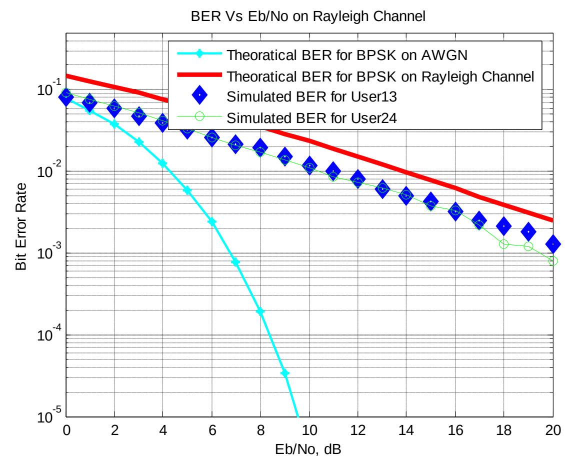


Figure 7: Probability of bit error rate Vs E_b/N_0 in WCDMA system using BPSK (with p1=0.7, p2=0.9, p3=1.3, p4 =1.5).

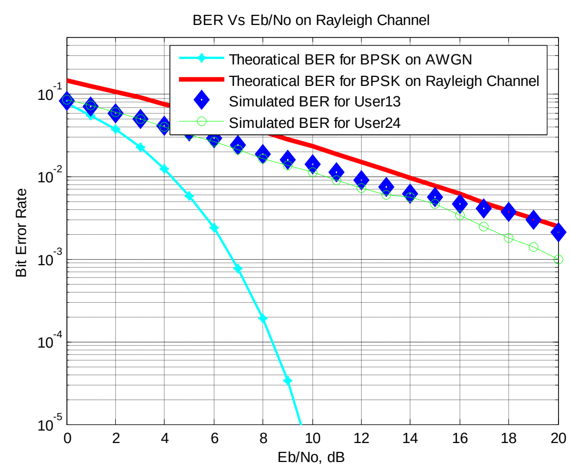


Figure 8: Probability of bit error rate Vs E_b/N_0 in WCDMA system using BPSK (with p1=1.5, p2=0.9, p3=0.7, p4 =1.2).

Figure 7 and 8 are shown the simulation result of the WCDMA system where BPSK modulation is used. It is shown from the figure that the signal passed through the AWGN channel and Rayleigh fading channel. When SNR increased then BER decreased along the signal passing through AWGN and Rayleigh fading Channel. Bit error rate BER is decreased when SNR increased but in AWGN BER is decreased earlier than Rayleigh fading channel.

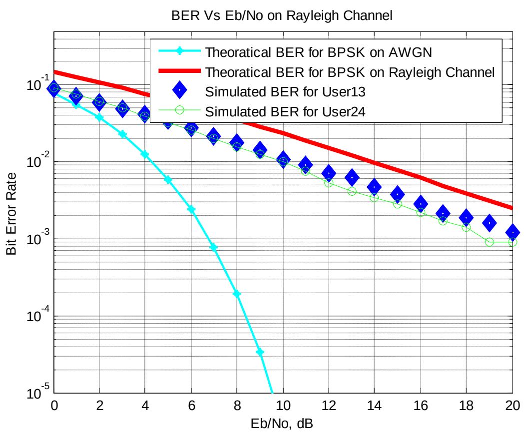


Figure 9: Probability of bit error rate Vs E_b/N_0 in WCDMA system using BPSK (with p1=1.0, p2=0.2, p3=1.7, p4 =1.2).

It is shown from figure 9, the result of the simulation is changed when power is changed then we got this graph. It is shown from the figure, theoretical and practical results are slightly changed from the previous simulation graph. Here theoretical and simulated results are slightly different when signal passed through the Rayleigh fading channel.

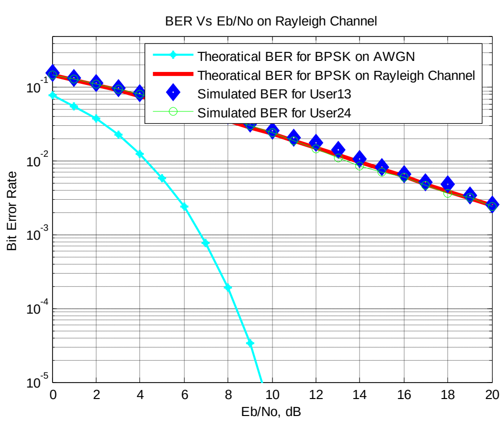


Figure 10: Probability of bit error rate Vs E_b/N_0 in WCDMA system using BPSK (with p1=0.9, p2=0.3, p3=0.3, p4 =0.5).

It is shown from the figure 10, simulated and theoretical results are closely related than previous figure. Here simulation and theoretical results for Raleigh fading are approximately same.

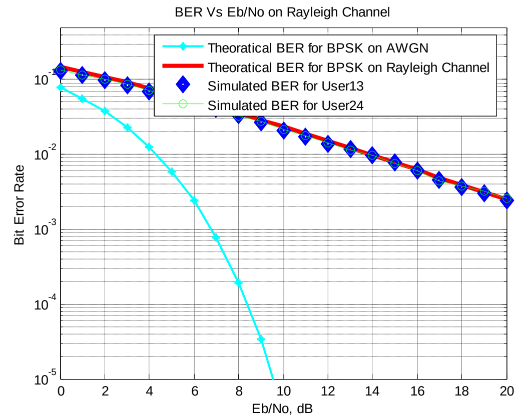


Figure 11: Probability of bit error rate Vs E_b/N_0 in WCDMA system using BPSK (with p1=0.5, p2=0.9, p3=0.7, p4= 0.2).

Here BER is removed with increasing SNR for both channels. But power is important for increasing SNR. When we increased power then SNR increased and BER is decreased but SIR introduced. So we have to adjust appropriate power to get desirable SNR and desirable signal.

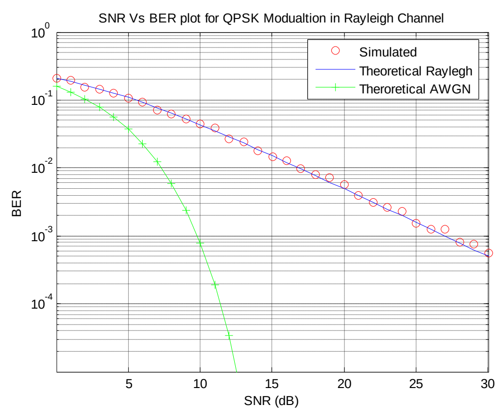


Figure 12: SNR Vs BER of WCDMA system using QPSK technique.

The bit error rate probability of the BPSK and QPSK modulation are different. In both BPSK and QPSK modulation bit error rate is lower. BER is lower in both cases using of AWGN channel. In BPSK bit error rate is minimized earlier than QPSK. In BPSK modulation, we increased SNR then BER is decreased and BER is completely removed at 10 dB while in QPSK modulation BER is completely removed greater than 13 dB for AWGN channel.

V. CONCLUSION

WCDMA which has been very attractive for future high rate wireless communication is providing high transmission data rate with high spectral efficiency. WCDMA system was simulated using MATLAB to allow various parameters of the system to be varied and tested. For small SNR values the calculated error rate was quite large and multipath fading was produced due to relative high power of noise. Bit Error Rate (BER) decreased as Signal to Noise Ratio increased (SNR). In QPSK modulation technique error is approximately zero for SNR value greater than 13 db while in BPSK modulation error is approximately zero for SNR value greater than 10 db, when signal passed through the AWGN channels.

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