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A Comparative Investigation on WCDMA Power Control Mechanisms

Muhammad Ahmed Sikander, Dr. Rashid Hussain, Adnan Ahmed Siddiqui, Sheeraz Arif, Syed Wasif Ali

Faculty of Engineering Science and Technology, Hamdard University, Karachi 74600, **(PAKISTAN)**

ABSTRACT

The main purpose of this research is to highlight the problems and advantages of both the power control mechanism and compare them accordingly. It has been investigated that open loop system is faster as compared to the close loop system as it has no long procedure or computations. It just have to compare the powers of MS (mobile station) and BS (base station) and increase / decrease the power. The present research mainly focuses on the comparison of WCDMA power control methods including, open and close loop methods, it further focus on channel transmission and signal-to-interference ratio (SIR). The channels used in controlling of power of WCDMA mobile networks are also investigated. Open loop power control has the limitations as it uses the same properties for both the directions of transmission as this is not the case every time practically or on the field. On the other hand close loop power control mechanism has a delay of 1/1.5 kHz (667 microseconds) but it is reliable because its power adjustment involves quality check and has a feedback path. It will be observed that close loop method is more reliable than the open loop method. Such an investigation will help an enhanced understanding of WCDMA technology and power control methods.

KEY WORDS: WCDMA, Cell Size, Loop, Transmission Power Control, Block Error Rate, Bit Error Rate.

1. INTRODUCTION

WCDMA is a radio access technique in UMTS and works on the physical layer of UMTS networks; it is also specified as (UTRA) Universal Terrestrial Radio Access Technique. It has a carrier signal of 5 MHz. It has a frequency reuse of approximately 1. It uses Direct sequence spread spectrum (DSSS). DSSS is one of the techniques used in digital signal transmission, in this technique the data which has to be transmitted is divided into small parts and assigned different channels in a spectrum [1, 2]. A signal is then combined by a code called chipping code or high data rate bit sequence. WCDMA has an efficient power control in order to minimize the interference in the network. It is also notified that power control is needed in both uplink and down link direction [3].

1.1 TECHNICAL FEATURES OF WCDMA

Some of the Key features of WCDMA are listed below [4, 5]

- Radio channels are 5 MHz wide.
- Chip rate of 3.84 Mcps
- Supported mode of duplex: frequency division (FDD), Time Division (TDD)
- Employs coherent detection on both the uplink and downlink based on the use of pilot symbols and channels.
- Supports inter-cell asynchronous operation.
- Variable rate transmission on a 10 ms frame basis.
- Multicode transmission.
- Adaptive power control based on SIR (Signal-to-Interference Ratio).
- Multiuser detection and smart antennas can be used to increase capacity and coverage.
- Multiple types of handoff (or handover) between different cells including soft handoff, softer handoff and hard handoff.
- 1:1 frequency reuse scheme

***Corresponding Author:** Muhammad Ahmed Sikander, Faculty of Engineering Science and Technology, Hamdard University, Karachi, 74600, (PAKISTAN) Email: m.sikander@hamdard.edu.pk Phone: +92(333)321-1392

2. POWER CONTROL IN WCDMA

WCDMA power control method is needed in both the directions including uplink and downlink. Uplink power control is needed to control near far effect which is created because of some mobile devices found close to base stations and other may be far away. Power control used to balance the power of near far user equipments in order to not make the near one superior. In downlink power control if signal transmit by more than one base station it is no more orthogonal and interfere with each other because as we know the neighbouring base station may be using the same downlink carrier so it is needed to control power and transmit data with minimal possible power. There are two types of UMTS power control mechanism, one is open loop and the other is close loop power control both are defined in figure 1[4,5].

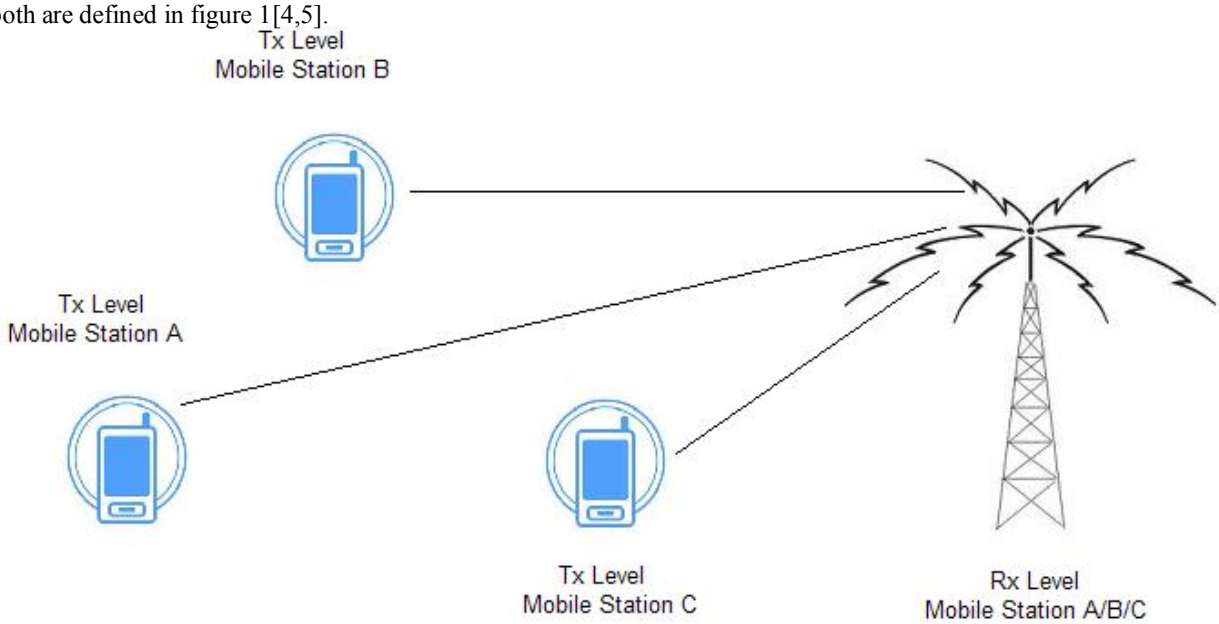


Figure 1: Near Far Effect: a) If no power control – Tx Level Mobile Stationa A = Tx Level Mobile Station B = Tx Level Mobile Station C -> Rx Level Mobile Station A < Rx Level Mobile Station B < Rx Level Mobile Station C b) With power control – Tx Level Mobile Station A > Tx Level Mobile Station B > Tx Level Mobile Station C -> Rx Level Mobile Station A = Rx Level Mobile Station B = Rx Level Mobile Station C [2,3,7]

2.1 OPEN LOOP

In this power control user device adjust the power level to a suitable value that can be suitable for receiver. It is used initially to set uplink power. The calculation is based on path loss and (SIR) Signal to interference ratio at cell receiver which comes out from (BCH) Broadcast Channel. [1,4]

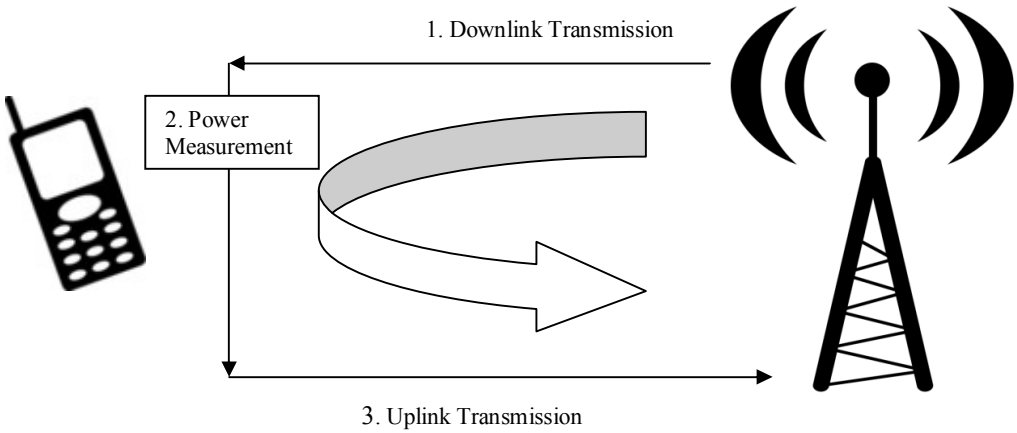


Figure 2: Open Loop Power Control

This method uses measurements made with the reception of signal through BCH (Broad cast channel) in downlink direction and decides power level for uplink direction. It's procedure is simple if the user equipment receive less power from base station then it is understood that the mobile station is away from base station and user equipment is required to increase power in uplink direction(figure above). This mechanism has a basic advantage that it is a quick power adjustment process but in this mechanism the power receive by the mobile station in downlink is used to decide the power level in uplink which is not a very good idea because it leads to the same fading conditions in up and down link which is probably not the case in WCDMA FDD mode, where the frequencies are different in both the direction of transmission.[6,8]

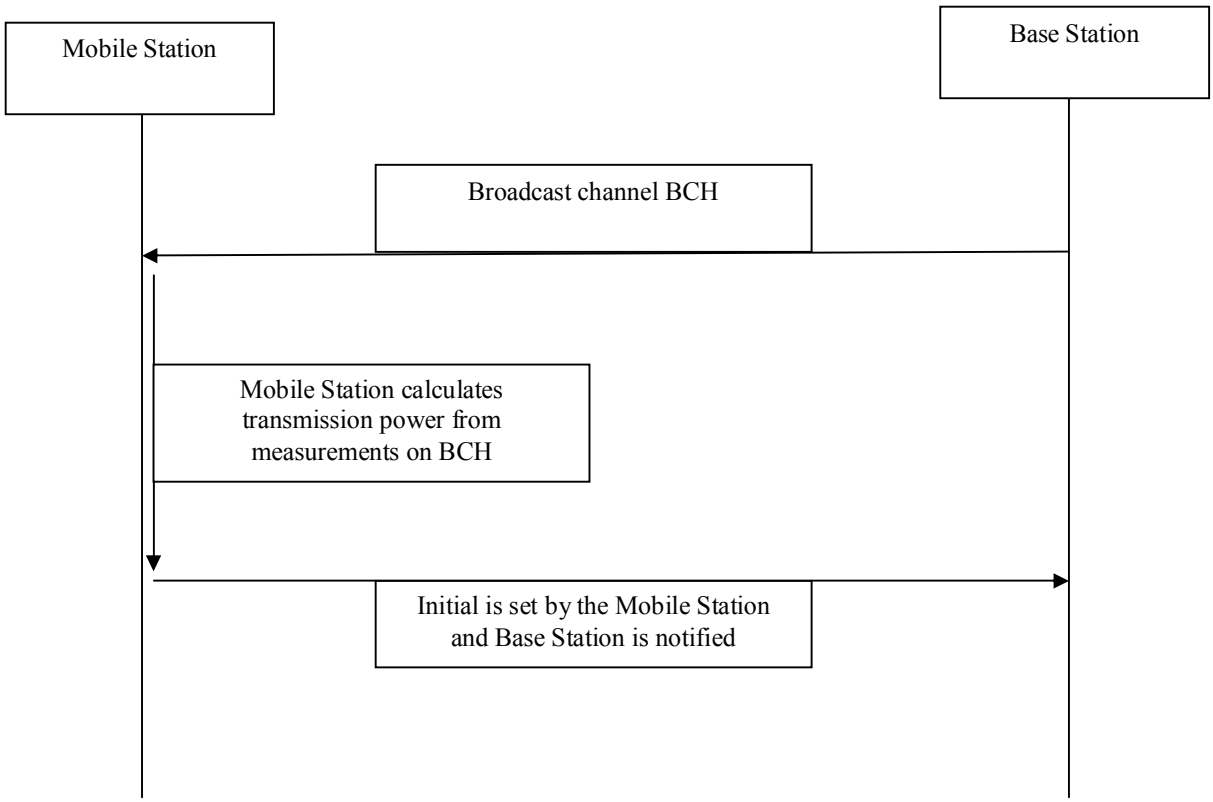


Figure 3: Flow chart illustrating the Open Loop control

It is basically used to initialized downlink and uplink transmission power when user equipment accessing the network. The tolerance of this control is 9db in normal condition and 12db in extreme condition.[1,4]

2.2 CLOSED LOOP

It is used to counter the uplink near far effect. In WCDMA fast power control is used which has a frequency rate of 1.5 kHz this rate perform both the action i.e. compensates both slow and fast fading. In this mechanism the power is measured the same manner as in the open loop but it uses the measured power in the same direction in which it has been calculated. This mechanism uses feedback loop which performs the measurement of quality on received signals and sends back the power adjustment commands to sending end. If the receiving quality of signal is low then the receiver will tell the sender to power up otherwise it tells the sender to decrease its power. In this mechanism SIR (signal to interference) ratio is used as a measurement of quality. The SIR_{target} is stored in the receiving end determines the quality needed to transmit. If the SIR measured at the transmitter side does not matches with the $SIR_{target,}$ then the sender is notified to increase/decrease power through a command bit called TPC (transmission power control). Figure 4 shows the process in uplink direction but it is the same as in the downlink direction [1, 2, 8.10].

As this process has more computation to perform as compared to the open loop, it has to speed up the process so as to counter this problem, in every 1/1.5 kHz i.e. in every 667 micro seconds base station calculate SIR (signal to interference ratio) of user equipment and compare it with SIR_{target} and send the command for power up / down. In reverse direction the feedback command is send with the transmitted data in that direction as a TPC bit. The operation which is defined earlier is divided into two parts mainly one is called inner loop and the other is called outer loop [2, 4, 10].

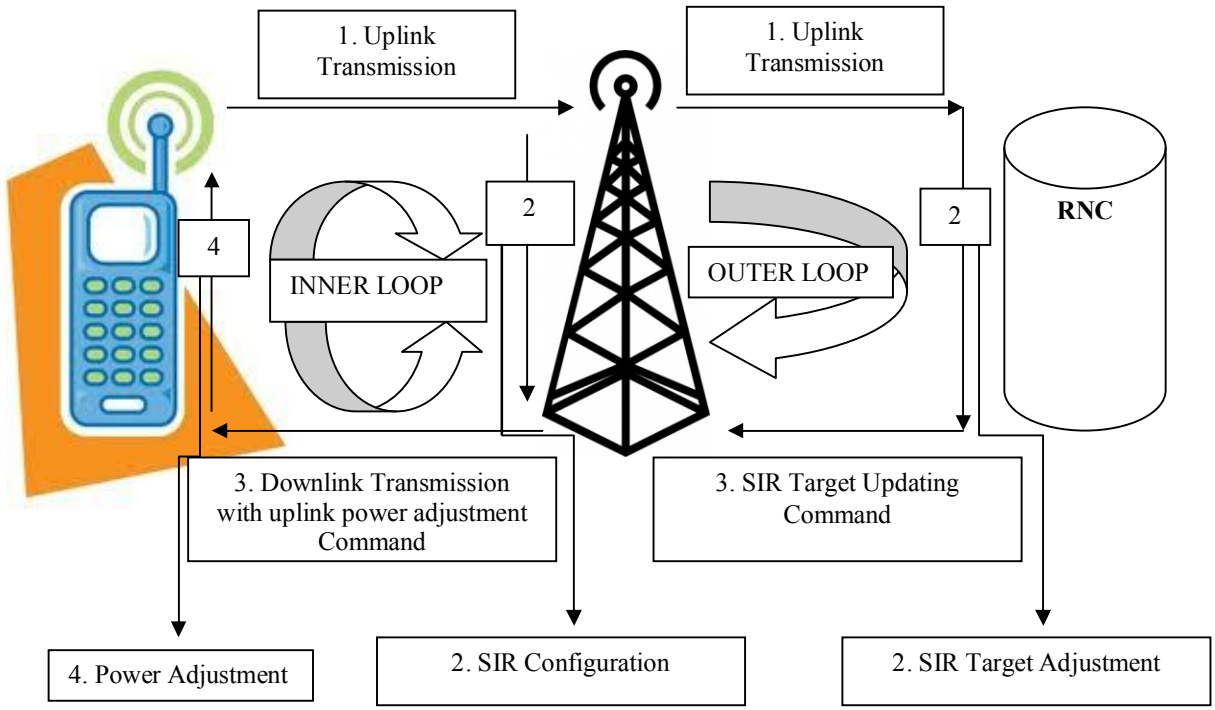


Figure 4: Illustration of Close Loop Power Control

Outer loop power control is used by RNC(radio network controller) to update the SIR_{target} value for base station using the values of BER(bit error rate) and BLER(block error rate), if BER/BLER is higher then it leads to increase in SIR_{target} value and to inform the base station.

3. Procedure

BER can be calculated using the general equation [2, 7, 10];

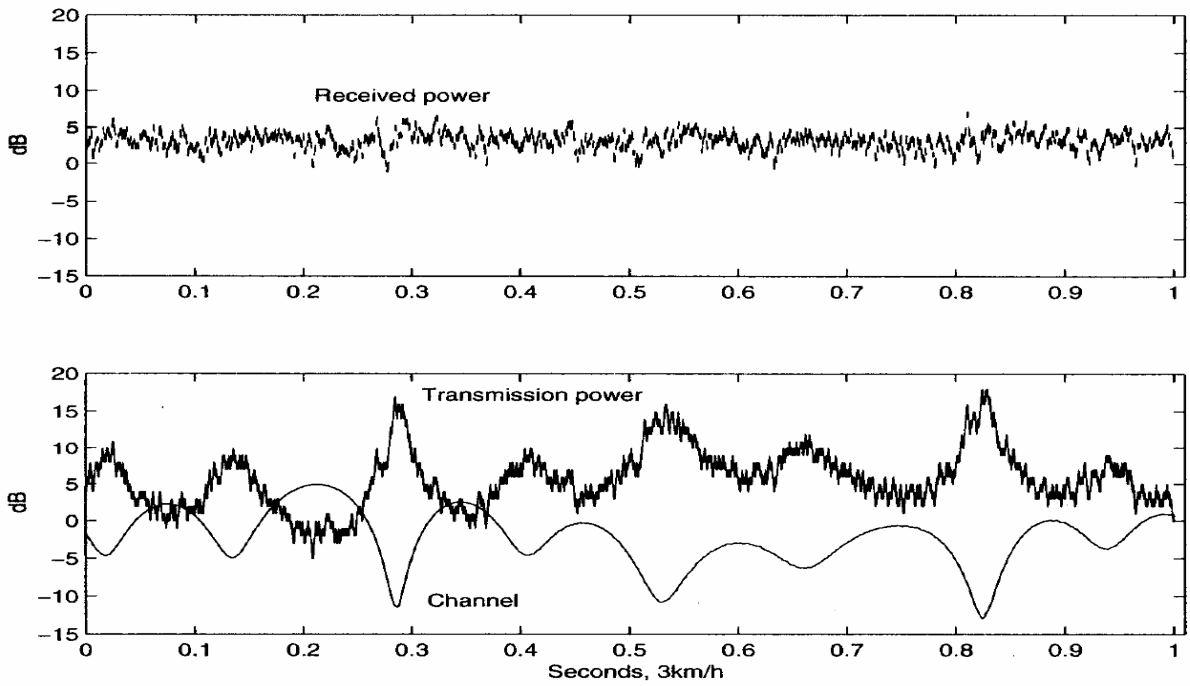
$$\mathbf{BER = p\ P(X>\_0) + (1-p)\ P\ (Y<\_0).} \qquad (1)$$

This equation is a general equation used to derive the most complicated equations for the BER as per requirement and data given at RNC.
In inner loop it compare the SIR_{target} with measured SIR value and sends command to user equipment to power up/down as required through TPC command the step size of TPC command is set by base station as per requirement but it is usually available in three modes 1db , 2db and 3db modes.[1,8] The chart is given,

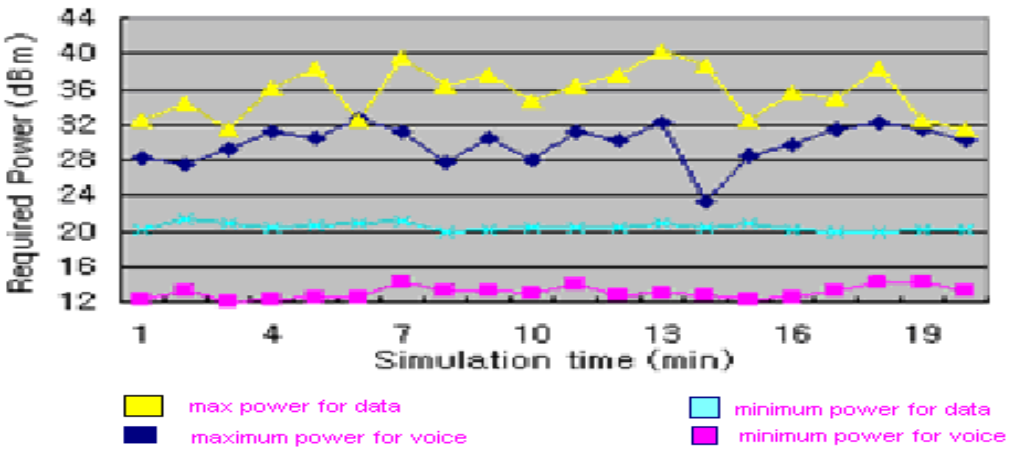
Table 2: TPC Command Table [3]

TPC_cmd	Transmitter Power Control Range					
	1 dB step size		2 dB step size		3 dB step size	
	Lower	Upper	Lower	Upper	Lower	Upper
+1	+0.5 dB	+1.5 dB	+1 dB	+3 dB	+1.5 dB	+4.5 dB
0	-0.5 dB	+0.5 dB	-0.5 dB	+0.5 dB	-0.5 dB	+0.5 dB
-1	-0.5 dB	-1.5 dB	-1 dB	-3 dB	-1.5 dB	-4.5 dB

3. GRAPHS FOR TRANSMITTED AND RECEIVED POWER LEVELS



Graph 1, 2: Received Power and transmitted power before power control [4]



Graph 3: Required Transmitted Power for Mobile Station [4]

The two graphs above shows the required, transmitted and received power at mobile station before any power control mechanism applied. The third graph defines the required power which is needed by the station to communicate with minimum BER as calculated by the Master Station controller. This graph defines two values: maximum and minimum, each for voice and data and will be achieved using close loop power control. The minimum value is the quantity at which the communication will trigger.

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CONCLUSION

In this research the importance of Power Control in WCDMA system has been discussed. The main purpose of this research is to highlight the problems and advantages of both the power control mechanism and compare them accordingly. As it has been discussed above that open loop system is faster as compared to the close loop system as it has no long procedure or computations. It just have to compare the powers of MS (mobile station) and BS (base station) and increase / decrease the power accordingly but it is not reliable because its nature allows it to be only used on the UTRAN (universal terrestrial radio access network) system in which uplink and downlink frequencies are same or otherwise use it to set power initially at the beginning of the connection. Open loop power control has the limitations as it is discussed above that uses the same properties for both the directions of transmission as this is not the case every time practically or on the field. On the other hand close loop power control mechanism has a delay of 1/1.5 kHz (667 microseconds) but it is reliable because its power adjustment involves quality check and a feedback path. It also divided into loops as define earlier which makes the load divided on the network and utilizes the same channel of transmission in reverse path. The discussion leads to the conclusion that close loop control is more reliable and efficient but it takes more time as compare to open loop but has quality maintained ability as justified above.

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