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Performance Enhancement of Closed Loop Power Control In Ds-CDMA

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ABSTRACT: Many times where the feedback delay between the mobile and the base stations is too low compare to the correlation time of the channel, closed loop power-control schemes using feedback from the base station can effectively compensate for the fast fading due to multipath. In this paper, we study several closed-loop power control (CLPC) algorithms by analysis and detailed simulation. We introduce a new non linear model for analyzing the received power correlation statistics of a CLPC scheme. The model provides analytical expressions for the temporal correlation of the power-controlled channel parameterized by the update rate, loop delay, and vehicle speed. The received power correlation statistics quantify the ability of closed-loop power control to compensate for the time-varying channel. To study more complex update method, detailed simulations that estimate the channel bit-error performance are carried out. Simulation results are combined with coding bounds to obtain quasi-analytic estimates of the reverse link capacity in a direct-sequence code-division multiple access (DS-CDMA) cellular system. The quasi-analytic approach quantifies the performance improvements due to effective power control in both single-cell and multi cell DS-CDMA systems operating over both frequency-nonselective and frequency-selective fading channels. The effect of dynamic base stations on the system performance is also presented.

Index Terms: feedback delay, closed-loop power control, fading rate, DSCDMA.

I. INTRODUCTION

Since the DS CDMA systems are inherently interference limited, it necessary to use closed loop power control to keep the signal-to-interference ratio (SIR) at nearly constant to the desire level [1]. In this case, power control is used to eliminate the near-far problem and usually called an open loop power control. Power control can also be used to combat the rapid fluctuation due to fading. For this purpose, we can employ closed loop algorithm in which the later will be our focus thorough this study. Unlike open loop algorithm, the mechanism of closed loop power control involves the base station to estimate the signal transmitted from mobile users. The signal estimation is then to be the base for power correction and fed back to that of mobile user for adjustment requirement. As consequence, this mechanism will require any delay either in processing or in propagating signal. This is agreed with [2]-[3]. In [2], delays account for signal measurement, synchronization between uplink and downlink and the propagation delay on the downlink. In [3] highlights that both measuring and signaling take time, which results in delay signals. The problem of feedback delay has been identified in [2]-[5]. In [2], [4], [5] feedback delay is the most critical in the loop.

The feedback delay effect is the most serious in the performance compared to the SIR measurement error and feedback transmission error [2]. In [4] states that the feedback delay due to propagation and processing was shown to be most critical parameter in the loop, and the error rate on the return channel to be the least critical. The result shows that the BER performance is sensitive to the feedback delay or the inverse of the power updating frequency [5]. In fact, most of studies separate between the feedback delay and setting of step size in design of power control. In this paper, we study closed loop power control by joining the setting of step size (1 dB and 2 dB) at the performance of system due to feedback delay. The performance will be evaluated in term of BER as a function of average SIR (*Eb/I0*). Our study is also conducted to see the effect of the other parameter (fading rate) on the system performance.

The rest of the paper is organized as follows. In section II, we describe the method of closed loop power control in CDMA Systems and present the feedback delay problem.The simulation and results are presented in section III.Section IV provides the conclusions.

II. POWER CONTROL AND FEEDBACK DELAY

In this study we have only focused on the reverse link closed loop power control. Closed-loop is solving the problem fluctuation due to small scale. Closed loop involves the base station to know the received signal quality through estimation of the channel information on the uplink. In this paper, we will use the channel information in the form of SIR or BER. This information is then compared with the desired target to produce power control command (PCC) and sent to the mobile user via forward link so that the mobile user can adjust its power level according to the PCC that being sent. Fig. 1 shows the model for reverse link closed loop power control.

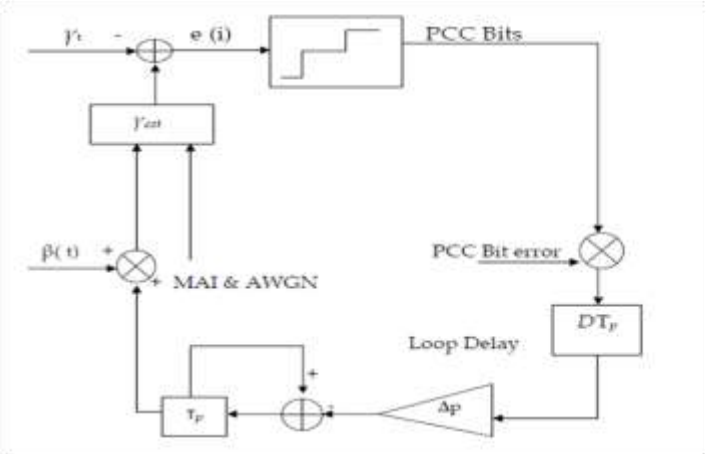

Figure 3.2 Mechanism of SIR-based power controls.

A mobile station receives the PCC bits and computes the required power adjustment, *Δp* x PCC. The step size *Δp* is preset at 1 or 2 dB and the PCC is either ± 1. In this study, we will only simulate the fixed step algorithm. In fixed step algorithm, only the sign of error signal is needed by the mobile to either increase or decrease its power by a fixed step size. If the estimated SIR, γest (i) is less than the target SIR, γt, the PCC bit of -1 sent to the mobile station to increase its transmit power by *Δp* dB. While if the estimated SIR, γest (i) is higher than the target SIR, γt, the PCC bit of +1 sent to the mobile station to decrease its transmit power by *Δp* dB.

In real system closed loop power control is imperfect due to the imperfection of power control itself and any factor in propagation environment that limits its performance to against fading. These factors include power update step size, power update rate and feedback channel error. Power update step size is the factor used by a mobile station to adjust its transmitted power at each power control interval. The power update step size is determined by the PCC bits or quantized feedback information *e(t)* which has been received by the mobile station. Power update rate *Tp* is defined as a rate by which the mobile transmit power is updated at each power control interval. To perform the power update rate we introduce theparameter *fDTp* which is defined as the ratio of the fading rate to the power update rate. Because of the power update rate is standardized at 1.5 KHz, the parameter *fDTp* will only depend on the fading rate *fD* [2]. As previously explained, the closed loop power contro lsystem must involve the number of process from channel estimation at BS until mobile adjustment is made. This situation indirectly will affect the performance of power control which in turn the performance is degraded due to delay when conveying the power control command information. This delay is called feedback delay and becomes inherent issue in any closed loop algorithm.

Feedback delay is simply defined as the total time from the channel is estimated at BS until the PCC is received at mobile station and power is adjusted accordingly.

III. ANALYSIS AND RESULT

Simulation in this final project used the work of reference [2] as starting point. We assume that the downlink channel is able to send the bit PCC command without errors. In this simulation, the open loop power control is assumed to be able to perfectly eliminate the near-far effect and shadowing problems. Therefore the closed loop power control is only used to mitigate the fluctuations due to the Rayleigh fading. To see how power control can work alone to mitigate the effect of fading, the simulation does not consider error control coding, interleaving nor applying the technique of rake receiver. In this study, a single path frequency nonselective fading is simulated so the using of rake receiver is not effective because there is only one resolvable path.

In addition, the slow fading is considered in this simulation that cause error control coding and interleaving are less effective. In the simulation, the system is considered as a singlecell CDMA with the number of user K=10. All users are in motion with different vehicle's speed to implement a practical situation. To model this situation, the user speed is made to vary from 6 to 60 km/h at 6 km/h interval. The system uses the carrier frequency fc = 1.8 GHz so the users has maximum Doppler spread ranging from 10 to 100 Hz at 10 Hz interval. The spreading factor M=64 is considered in this simulation. The scheme of modulation is QPSK with a bit rate Rb = 120 kbps related to the symbol rate Rs = 60 kilo symbol/s in QPSK. In according with 3G specification, the power update rate=1.5 KHz. Therefore the mobile power is updated in each interval Tp = 0.667 ms. SIR Estimation is performed in every timeslot that corresponds to one power control interval Tp. The chip rate Rc = 3.84 Mcps as given in 3G standard for uplink data channel. With this chip rate, each timeslot contains 2560 chips representing 40 symbols. All symbols in the timeslot are utilized by SIR estimator to estimate the SIR. The AWGN with the noise variance σn 2 = 7 dB below the signal power is added to simulate the receiver thermal noise.

Therefore the composite signals at the base station consist of all users' signal and AWGN. The simulation parameters are summarized in Table 1

A. Simulation 1 Step size is small

The simulation 1 evaluates the effect of feedback delay on the performance of system applied low step size (1 dB). The system is simulated for low speed, moderate and higher speed or users whose have the fading rate fD= 50 Hz, 80 Hz and 100 Hz, respectively. From the simulation 1, we can see that the best performance is achieved for low speed user with the fading rate=50 Hz. This because of the power control is updated more frequently. In fading rate=50 Hz, the frequency update power control $fDTp$= 30 times faster than fading rate. It is different for fD = 80 Hz and 100 Hz in which $fDTp$= 18 times
for fD = 80 Hz and $fDTp$= 15 times for fD=100 Hz faster than fading rate.

Table i. Simulation parameters

Parameter	**Notation and Value**bi
Number of Users	$K = 10$
Carrier Frequency	fc = 1.8 GHz
Vehicle's Speed	$Vk = 6.K$ km/h $K=1,2, \ldots,K$
Max Doppler Spread	$fD = 1.67\ VK$ Hz
	(Vk =6, 12, …, 60km/h)
Data Bit Rate	Rb = 120 Kbps
Chip Rate	Rc = 3.84 Mcps
Processing Gain	$M = 64$
Power Control Interval	Tp = 0.667 ms
Power Update Step Size	Δp = 1 dB and 2 dB

The graphic for performance of system with fD= 50 Hz is shown in fig. 2. In this figure, the best performance is achieved at feedback delay=1 Tp. The better performance is obtained at feedback delay=2 Tp. At feedback delay=3 Tp, the system almost unable to perform its performance because the system is close to the fading performance (performance without power control). Fig. 3 shown the system performance for fD=80 Hz. In this fading rate, the power control is updated 18 times faster than fading rate. In system with fD=80 Hz, the performance at feedback delay=1 Tp is the best achievable performance. This performance is lower than the obtained performance at fading rate=50 Hz. This result has valid because its power control is updated lower than the system at fading rate=50 Hz. At feedback delay=2 Tp, the performance almost close to the fading performance. At most of Eb/Io, the BER performance at feedback delay=3 Tp is worse than the BER theoretic (BER performance for fading channel) in this study.

Figure 2 Performance at Step size =1dB, Fading Rate =50Hz

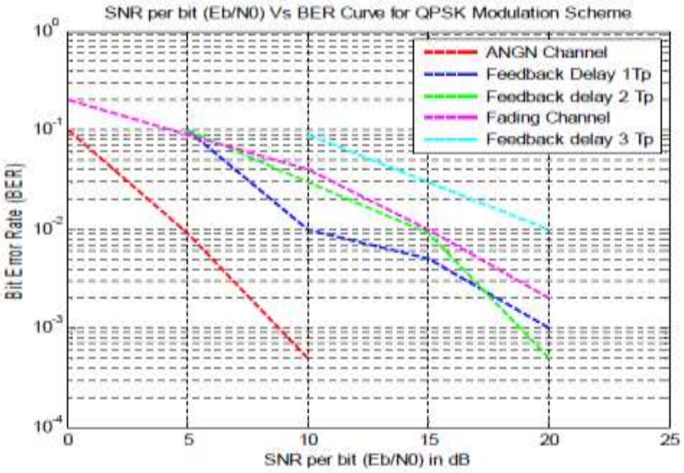

Figure 3 Performance at Step size =1dB, Fading Rate =80Hz

The last graphic for system 1 dB is shown in fig. 4. This graphic shown the performance of system at fading rate=100Hz. In fading rate=100 Hz, the mobile transmit is updated 15 times faster than fading rate. If frequency update of power control is lower than the fading rate then the fading

fluctuation is less able to be tracked. This situation leads to

the degradation of the performance even the performance is close to the fading channel. In fig. 4, the performance at feedback delay=1 *Tp* is still in the bottom of figure and slightly better than the others. The intermediate figure and the top figure are the performance at feedback delay=2 *Tp* and 3 *Tp*, respectively. Due to the higher fading rates, system with feedback delay=2*Tp* and 3 *Tp* at *fD* =100 Hz is unable to show its performance since the obtained BER are around the fading

performance. For all fading rates, the higher the feedback delay, the worse the performance of power control. This is because the update power that transmitted by the mobile station is out of date and no longer represents the fading condition particularly in higher feedback delay that resulting in deviation of the SIR from the target level.

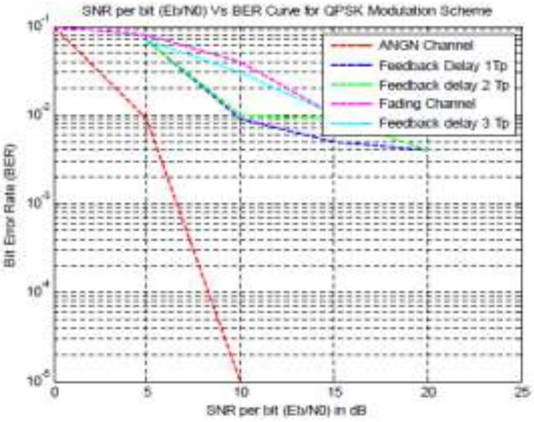

Figure 2 Performance at Step size =1dB, Fading Rate =100Hz

As previously mentioned, in *fD*=80 Hz and 100 Hz, the BER performance at system with feedback delay =3 *Tp* is worse than the theoretic BER for performance without power control. In fact in fading rate= 50 Hz with *fDTp*= 30 times higher than the fading rate, the performance with feedback delay= 2 *Tp* and 3 *Tp* are much worse with the increasing in delay.

B. Simulation 2 Step size is large

The simulation 2 evaluates the effect of feedback delay on the performance of system used step size=2 dB. For all feedback delay, the best performance is still achieved for low speed user in fig. 5 with fading rate= 50 Hz. In low speed, the power control is updated more frequently than the others user with higher speed. For step size= 2 dB, deep fades at fading rate= 50 Hz can be tracked more quickly. This will result the better performance at the same fading rate at the system that use the step size=1 dB. In fig. 5, we can observe that performance with the fading rate= 50 Hz at feedback delay=1 *Tp* is better than the performance of system as result 1 that employed the step size=1 dB. Due to higher step size, we have found that the performance of 2 dB with feedback delay=2 *Tp* is better than the performance of 1 dB at *Eb/Io* higher than 10 dB. For feedback delay=3 *Tp*, the system with the step size= 2 dB is fail to improve the performance because of higher feedback delay. In case of 2 dB, the higher feedback delay cause the performance degraded above the fading performance. In fig. 6, we will see and analyze the performance of 2 dB at fading rate *fD*=80 Hz. From fig. 6, the performance with feedback delay=1 *Tp* is still better than the system 1 dB due to the higher step size. The performance for *fD*=80 Hz with feedback delay=2 *Tp* is better than the system 1 dB only at higher *Eb/Io*. At lower *Eb/Io*, the better performance is achieved by the system 1 dB. In higher fading rate, the mobile with higher fluctuation must be operated with higher *Eb/Io* to obtain the enough BER and otherwise for lower fading rate. This is agree with result 1 at fig. 3 for *fD*=50 Hz at feedback delay=2 *Tp* in which the better performance for system 1 dB is achieved at lower *Eb/Io*.

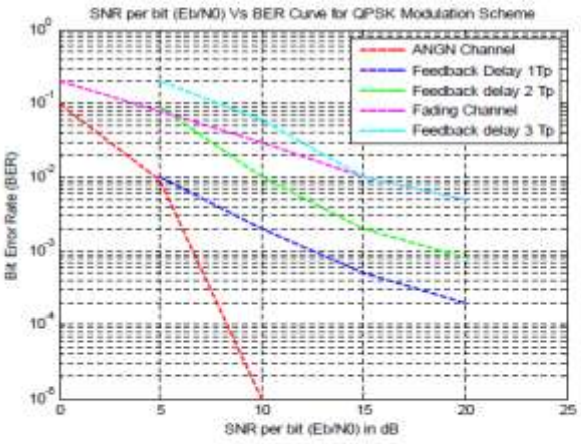

Figure 5 Performance at Step size =2dB, Fading Rate =50Hz

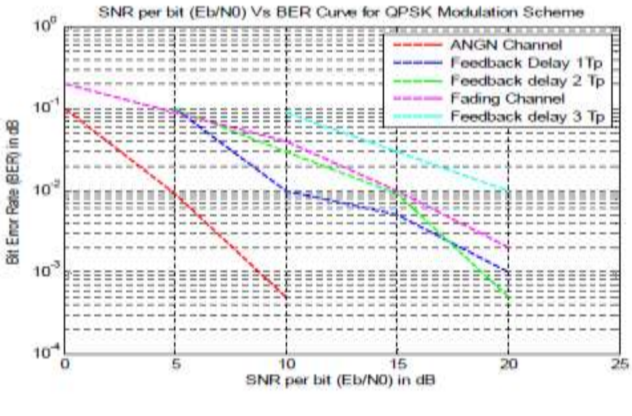

Figure 6 Performance at Step size =2dB, Fading Rate =80Hz

This because at lower fading rate, deep fades are less frequently, so that tracking by using lower step size is more effective than using higher step size to obtain the enough BER. Although the system 2 dB has higher tracking against fading, but since *fDTp* is lower, the step size does not give advantage on the system for this fading rate. Due to longer feedback delay, the BER performance of system 2 dB with feedback delay=3 *Tp* is worse than the BER theoretic for fading performance.

Finally, we will see the analysis for system performance at fading rate=100 Hz that shown in fig. 7. In fading rate=100 Hz, the performance 2 dB at feedback delay=1 *Tp* is still better than system 1 dB. This is due to higher tracking ability of the system 2 dB. The system at feedback delay=2 *Tp* is similar with the fading performance while at feedback delay=3 *Tp* the system 2 dB is worse than the BER theoretic for fading performance.

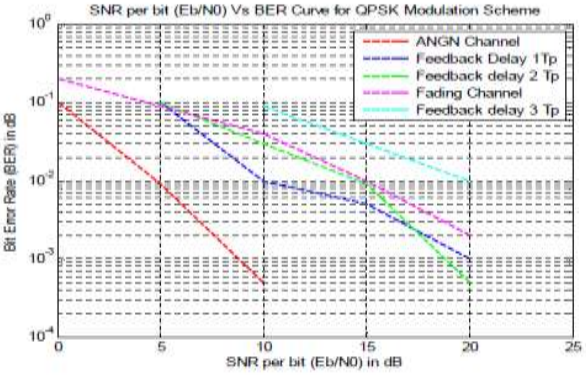

Figure 6 Performance at Step size =2dB, Fading Rate =100Hz

We have seen for all fading rates, the BER performance at system 2 dB with feedback delay=3 *Tp* are worse than the system 1dB and almost worse than the BER theoretic for fading performance. In other words the system with step size=2 dB is less applicative at higher feedback delay.

IV. CONCLUSIONS AND FUTURE WORK

Feedback delay affects the performance of closed loop power control in CDMA system. In all figures from the result 1 and result 2, the performance is degraded with the increasing feedback delay. This is because the update power that transmitted by the mobile station no longer represents the fading condition. From result 1 and result 2 we can conclude that the performance is also degraded with the increasing on fading rate. The increasing on fading rate will generate deeper fade that is more difficult to be tracked with small step size. In case of fading rate, we can consider that power control is not properly work in higher fading rate e.g. fading rate=100 Hz

The performance is also affected with the design of step size at mobile station. In relation to the step size, we have seen that the setting of 1 dB is more appropriate for higher feedback delay e.g. feedback delay=3 *Tp* while system of 2 dB is more appropriate for lower feedback delay e.g. feedback delay=1 *Tp*. If the total feedback delay can be minimized e.g. until 1 *Tp*, then the application of 2 dB will be better than 1 dB. Conversely, if total feedback delay is difficult to be minimized, then the system of 1 dB is more applicative for higher feedback delay. Therefore, there is a tradeoff between step size=1 dB or 2 dB to be created at mobile station. But from the perspective of efficiency in received power (that correspondence with the capacity), we have found that the system of 1 dB is better than the system of 2 dB at feedback delay=2 *Tp*. In this case, a mobile user can still operate at lower *Eb/I0* with implies many users can be served at base station. As the end of section, we conclude that the system of
1 dB generally is still better than 2 dB from aspect of delay and capacity.

REFERENCES

[1]. Filyal Fahri and Dwi Astharani, "Feedback Delay Effect on the CDMA Closed loop power control ", Second International Conference on Advances in computing telecommunication technologies, 2010.
[2]. A. Kurniawan, Predictive Power Control in CDMA Systems, Ph.D Dissertation. Institute for Telecommunication Research, University of South Australia.
[3]. A.Chockalingam, P. Dietrich, L. B. Milstein and R. R. Rao "Performance of Closed-Loop Power Control in DS-CDMA Cellular Systems," IEEE Trans. Vehicular Technology, vol.47, pp. 774-789,
[4]. M. L. Sim, E. Gunawan, C. B. Soh, and B. N. Soong, "Characteristics of Closed Loop Power Control Algorithm for a Cellular DS/CDMA System," IEE Proceedings-Communications, vol. 145, no. 5, pp. 355-362, October 1998 .
[5]. K. S. Gilhousen, I. M. Jacobs, R. Padovani, A. J. Viterbi, L. A. Weaver, Jr., and C. E. Wheatley III, "On the capacity of a cellular CDMA system," IEEE Transactions on Vehicular Technology, vol. 40, no. 2, pp. 303-312, May 1991
[6]. A. J. Viterbi, A. M. Viterbi, and E. Zehavi, "Performance of power-
[7]. controlled wideband terrestrial digital communication," IEEE Transactions on Vehicular Technology, vol. 41, no. 4, pp. 559-569, April 1993.
[8]. F. Simpson and J. M. Holtzman, "Direct sequence CDMA power control, interleaving, and coding," IEEE Journal on Selected Areas in Communications, vol. 11, no. 7, pp. 1085-1095, September 1993.
[9]. S. Y. Seidel, T. S. Rappaport, S. Jain, M. L. Lord, and R. Singh, "Path loss, scattering and multipath delay statistics in four European cities for digital cellular and microcellular radiotelephone," IEEE Transactions on Vehicular Technology, vol. 40, no. 4, pp. 721-730, November 1991.362, October 1998.
[10]. K. Allsebrook, and J. D. Parsons, "Mobile radio propagation in British cities at frequencies in the VHF and UHF bands," IEEE Transactions on Vehicular Technology, vol. VT-26, no. 4, pp. 313-323, November 1977.
[11]. S. Soliman, C. Wheatley, and R. Padovani, "CDMA reverse link open loop power control," in Proceedings IEEE Global

Telecommunications Conference, vol. 1, December 1992, pp. 69-73.