# BER PERFORMANCE ANALYSIS OF OPEN AND CLOSED LOOP POWER CONTROL IN LTE

ADAM M. A. ABDO*

MOHAMED H. M. NERMA*

MOHAMMED A. A. ELMALEEH**

AMIN B. A. MUSTAFA***

MUAWIA M. AHMED***

**_Abstract_**

The power control (PC) policy in Long Term Evolution (LTE) network is important issue, the interference of cell user to neighbour cell is consider to avoid any annoying to close cells. In this paper the two uplink PC scheme close loop power control (CLPC) and open loop power control (OLPC) are modelled in order to investigate the effects of Mobile cell edge to another cell and show how to adjust the user power according to two path losses. The algorithms were simulated by using MATLAB program. The open loop technique considered that the strongest interference is caused by mobile to neighbour cell, while the power control components is adjusted continuously in the close loop technique . The effects of CLPC and OLPC are shown in term of throughput, path loss, power spectrum density (PSD) and the bit error rate (BER). Results shows that the CLPC is outperform the OLPC in term of throughput, PSD and path loss; while they are perform similarly in term of BER.

***Keywords:*** LTE, Interference, OLPC, CLPC, BER, SINR, PSD, Throughput and Path loss.

* College of Engineering, School of Electronic Engineering, Sudan University of Science and Technology, Khartoum, Sudan

** Faculty of Engineering, Department of Electrical and Electronic Engineering, No 433, Block, 16, Jebrah, Khartoum, Sudan

*** Faculty of Engineering, Neelain University, Khartoum, Sudan

## I. Introduction

Constraints on the available radio spectrum, owing to a continuous evolution and innovations in the field of Telecommunications affect adversely the development of Mobile Communications. The introduction of high data rate multimedia mobile services in the next generation Mobile Communication Systems such as multimedia services (MMS), video calls, TV on phone, Internet etc, require a huge amount of bandwidth. There is an ever-growing demand on the limited radio resources with the burgeoning number of mobile phone users. Consequently, an efficient use of radio resources has become an imperative global challenge [1].

Among different radio resource management (RRM) techniques, power control (PC), also known as transmit power control (TPC), is one of the important interference suppression techniques. The system capacity and performance are adversely affected and degraded by interference. Hence, PC plays a prominent role in an interference limited system, which increases the efficiency by mitigating the adjacent and co-channel interference in the system [2].

PC is applied to systems where users interfere with each other. The goal of PC is to adjust the transmit powers of all users such that the signal to interference ratio (SINR) of each user meets a given threshold required for acceptable performance. This threshold may be different for different users, depending on their required performance. This problem is straightforward for the downlink, where both users and interferers have the same channel gains, but is more complicated in the uplink, where the channel gains may be different [3]. The Femto cell uplink throughput has been improved by applying a decentralized frequency domain stochastic scheduler (FD-SS) in Femtocell base station (FBS) together with uplink power optimization [4].

The fractional power control (FPC) algorithm by simulation and evaluates possible tuning of this algorithm and its effects on service performance on both user terminal (UE) and system performance improvements has been studied in [5]. Analytical approach for the FPC compensation factor which gives good results has been proposed in [6], however this works analyzed FPC compensation factor and don't consider the two category of FPC (fast power control and slow power control) according to the channel variation.

The objective of this paper is to design and implement the CLPC and OLPC schemes in combination with the fractional path loss compensation factor for the physical uplink shared channel (PUSCH) and show the effect of these two techniques on different performance parameters like the throughput, PSD, path loss and focusing mainly on the BER.

## II. *System Description*

To manage this interference will introduce the open loop and close loop idea, in this method how to reduce the variance and average of total interference PSD. Apply two scheme (CLPC and OLPC), and calculate transmit power of each user according to algorithms.

## III. *System Design*

In figure 1, UEs 1 and 2 are served by the first eNodeB and UE 3 is served by the second eNodeB. The path losses from the clients to eNodeBs are marked in the figure 1. Assume no shadowing or fast fading. Assume that FPC with Eq. (2) is applied where $P_0 = -86$ dBm, $\alpha = 0.8$, $\delta_i = 0$, and $PSD_{max}$ is not reached. It can be computed that when UEs 1 and 2 are scheduled to transmit, their transmission PSD is 14 dBm and 16.4 dBm, respectively. They create interference of -121 dBm and -112.6 dBm to eNodeB 2, respectively. Suppose that is the only interference when UE 3 transmits in cell 2. The resulting signal to interference ratio (SIR) values for UE 3 are 9.6 dB or 1.2 dB, depending on whether UE 1 or UE 2 is scheduled in cell 1. Mathematically the uplink FPC [7] is described by the following equation:

If the UE_i adjust transmit power $P_i^T$ in dBm then,

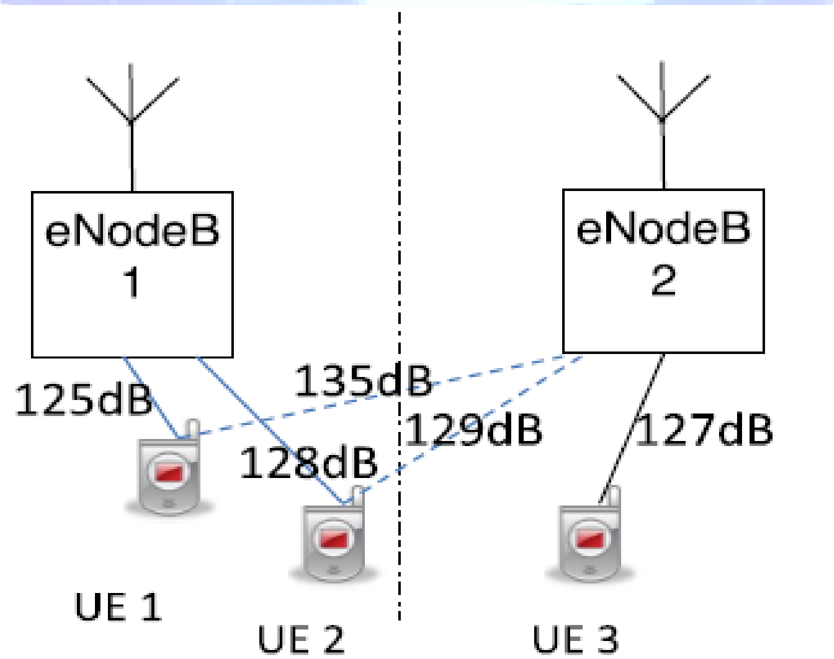


Figure 1: Example of two cell scenario.

$$P_i^T = \min\{ P_{max}, P_o + \alpha PL_{DL,i} + 10\log_{10}(M) + \delta_i \} \quad (1)$$

where $P_{max}$ is total power of user i, and $P_o$ is desired received power for each resource block (RB), $PL_{DL,i}$ is dawn link path loss and shadowing, M is number of RBs located to user, $\alpha$ is compensation factor and $\delta_i$ is user dependent power control component. The PSD of user i is total power divided by number of RBs (M).

$$PSD_i = \min\{ PSD_{max}, P_o + \alpha PL_{DL,i} + \delta_i \} \quad (2)$$

where $PSD_{max} = P_{max} - 10\log_{10}(M)$.

**A. Open loop Scheme**

In an open loop scheme every UE_i estimate the downlink path loss including the shadowing for serving cell and downlink path loss for the strongest interfere neighboring cell and select the power UE_i according to equation (3) [7], [8].

$$PSD_i = \min\{PSD_{max}, P_o + \alpha PL_{UL,i} + \delta_{max}, \Gamma_\circ + PL_{UL,i}^{strNB}\} \quad (3)$$

where $P_o$ is desired received PSD, $\Gamma_\circ$ is the interference of PSD target for all cells and $PL_{DL,i}^{strNB}$ is strongly interference caused by user to neighboring cell.

**B. Closed Loop Scheme**

In this case the equation (2) will use, but the value of user dependent power control component $\delta_i$ is adjusted continuously. Update of power control component ($\delta_i$): Let $p_{s\to b}^c(t)$ is received interference power on RB c from UE served by cell eNodeB s to eNodeB b at time t. note eNodeB b is no need to know which user served by eNodeB s transmit at time t [8]. The received interference of user served by eNodeB s from eNodeB b is calculated as

$$P_{i,b}^{\sim}(t) = \frac{1}{|I_i(t)|} \cdot \sum_{c \square I_i(t)} P_{s\to b}^c(t) \quad (4)$$

where $I_i(t)$: is set RBs which assigned to user i in cell s at time t. Now the exponential moving average interference PSD $p_{i,b}^{-}(t)$ of user i in cell s is given by:

$$P_{i,b}^{-}(t) = (1-\beta)P_{i,b}^{-}(t-T) + \beta(P_{i,b}^{\sim}(t) - \delta_i(t)) \quad (5)$$

If UE_i is scheduled at time t. Otherwise: $P_{i,b}^{-}(t) = P_{i,b}^{-}(t-T)$.

where T is power control period and $\beta$ is positive small value to make system fast during startup and can be set as: $\beta = \max(\beta_\circ, \frac{1}{t/(T+1)})$, where $\beta_\circ$=0.02. The serving eNodeB s finds the neighbor which had highest interference from cell eNodeB b as: $b^{\wedge}$=argmaxb $P_{i,b}^{-}(t)$. The adjustment $\delta_i(t+1)$ is given by:

$$\delta_i(t+1) = \min\left(\Gamma_\circ - p_{i,b}(t)\,,\ \delta^{max}\right) \tag{6}$$

If a UEs power is reduced so very much due to random fluctuation, its achievable rate be very small , that it will never get scheduled, to avoid this scenario the counter $f_i$ will be set which counts times of UEs is scheduled at last power control event, if it is below the certain threshold then $\delta_i(t)$ increased by small amount $\Delta > 0$ [8]. Then,

$$\delta_i(t+1) = \min(\delta_i(t) + \Delta\,, \delta^{max}) \tag{7}$$

## IV. *Simulation Methodology*

In this paper the two algorithm simulated for cell edge user, in an OLPC consider the two path loss: path loss of user mobile to serve base station as shown in equation (3) and the path loss of strongest interference caused to neighbor cell and also the maximum power considered these three values determine how the user power is adjusted to avoid effects on neighbor cell and maintain transmit power on acceptable level. On CLPC the system must update power control component $\delta_i$ continuously and as in equation (2) the power of user must set according to its value.

## V. *Results and Discussion*

Figure 2 show the relationship between distance and the path loss. as shown in figure 2 the path loss of LTE mobile user for the signal that is to served base station (BS) (the sold red curve) is increase exponentially with distance and the path loss of mobile signal that is interfere to neighbor cell as uplink interference (the sold green curve) is increased linearly with distance because the distance is large compared to serve cell.

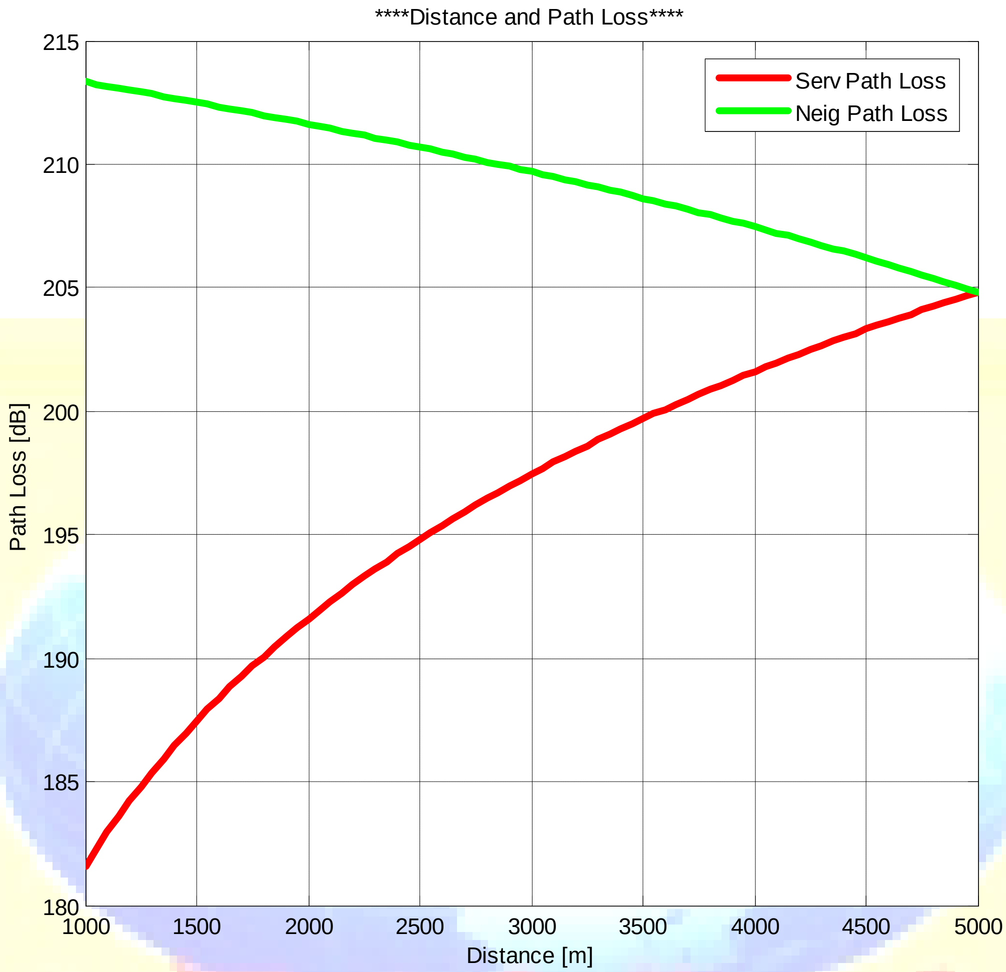


Figure 2: the path loss of serving mobile cell and neighboring cell.

Figure 3 and figure 4 show the performance of the throughput and power for the two algorithms (OLPC and CLPC). Figure 3 shows the result for iteration is 1000 times while figure 4 shows the result for iteration is 10000 times. From figure 3 and figure 4 we conclude that for same amount of power the CLPC (the sold green curve) outperform the OLPC (the sold blue curve) in term of the throughput.

Figure 5 shows the result of the throughput and SINR for both OLPC and CLPC. Result in figure 5 shows that for high values of SINR (greater than 7 dB) the CLPC (the sold blue curve) gives better result than the OLPC (the sold black curve) in term of the throughput.

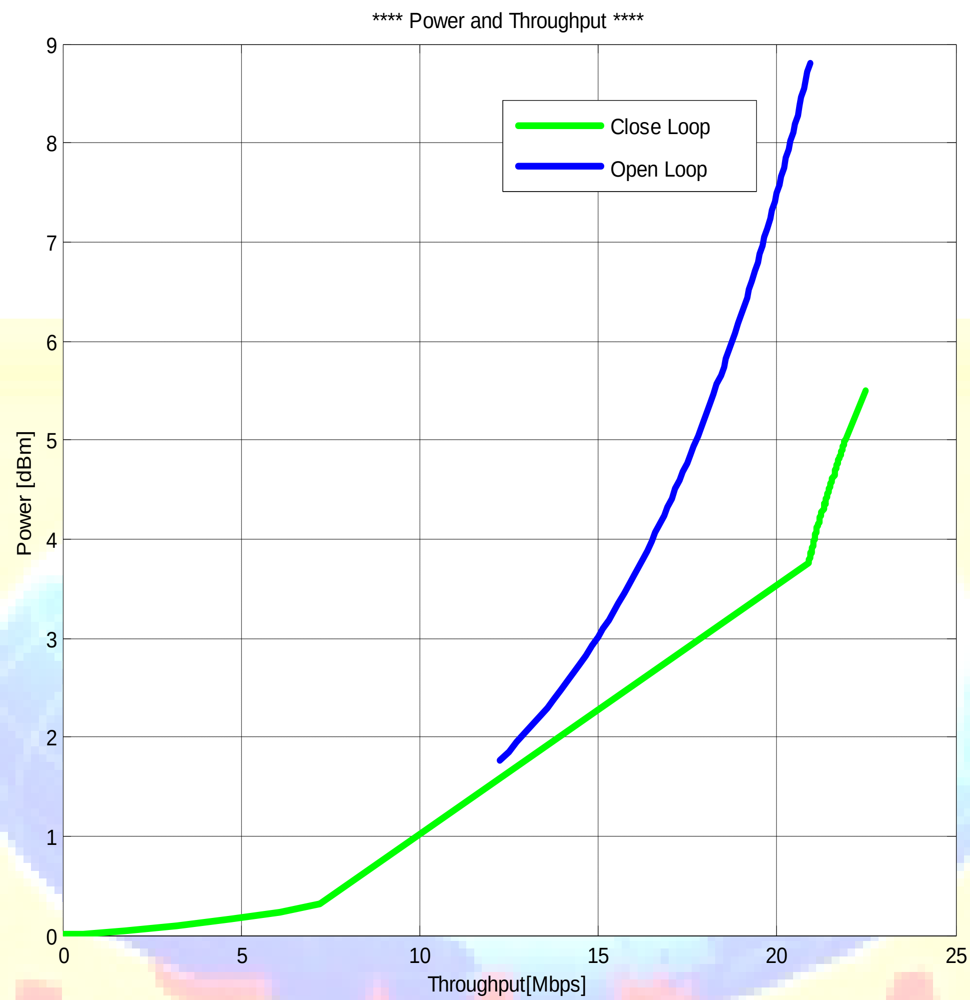


Figure 3: Throughput for OLPC and CLPC (iteration is 1000 times).

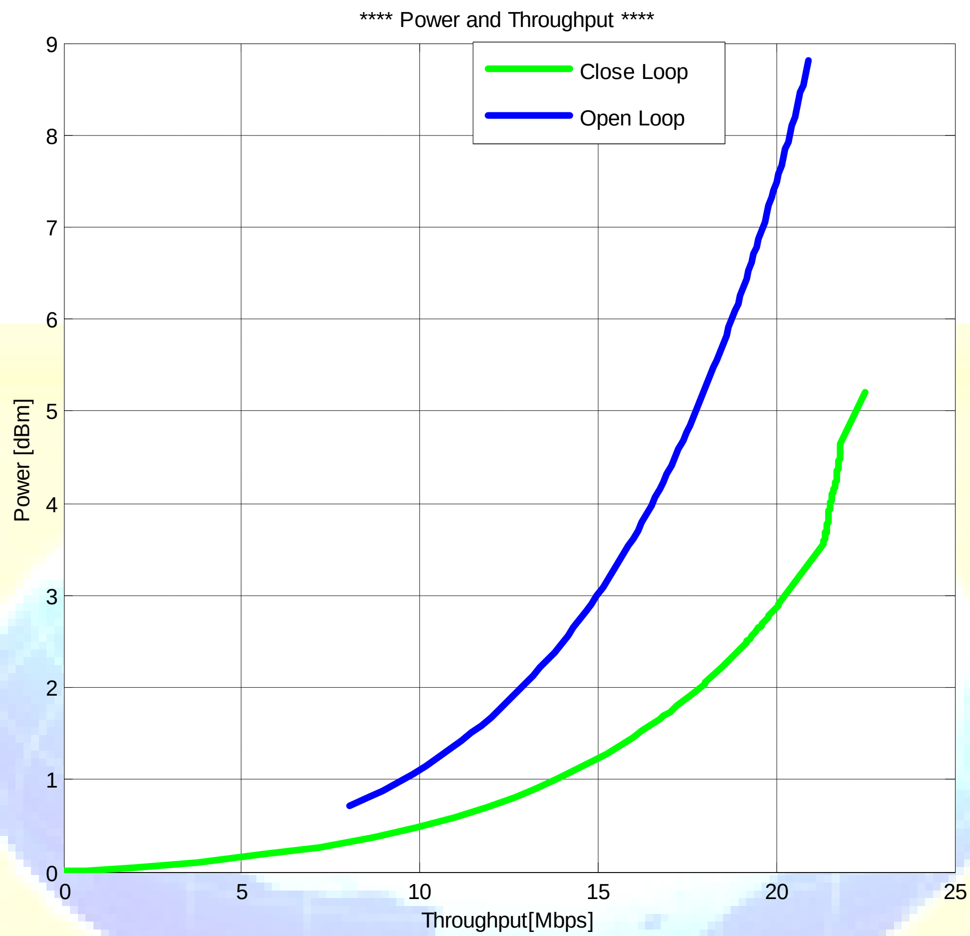


Figure 4: Throughput for OLPC and CLPC (iteration is 10000 times).

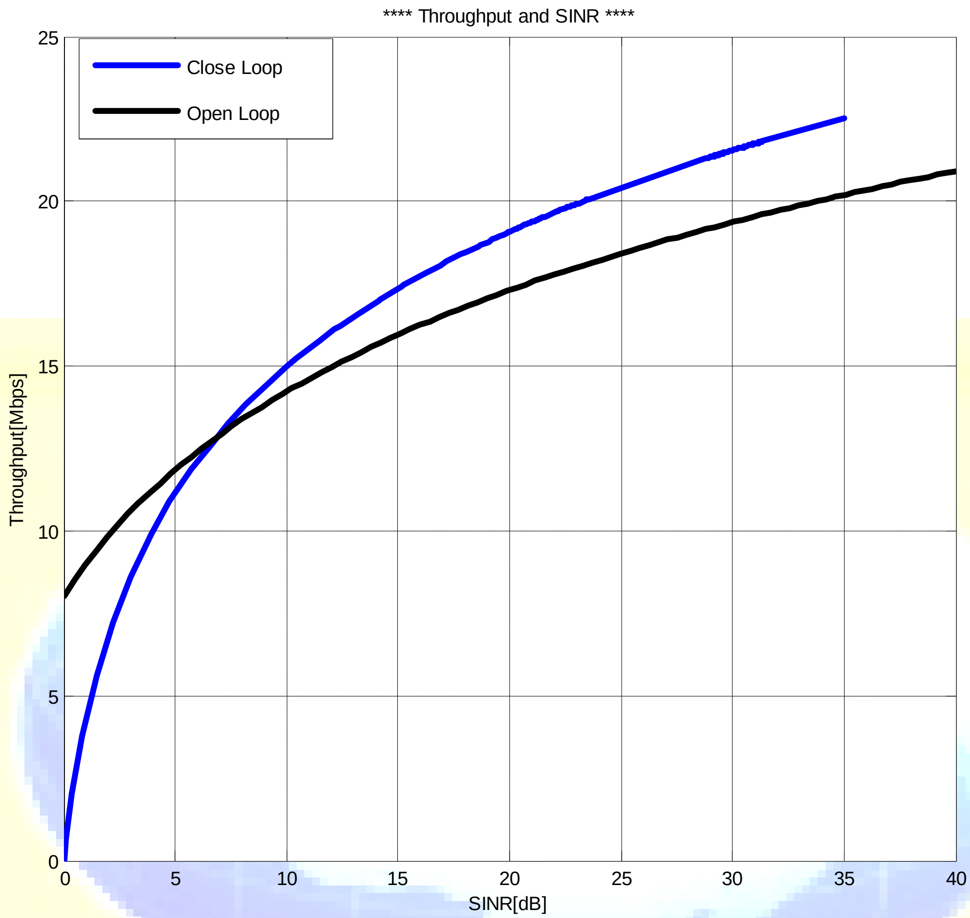


Figure 5: Throughput versus SINR for OLPC and CLPC.

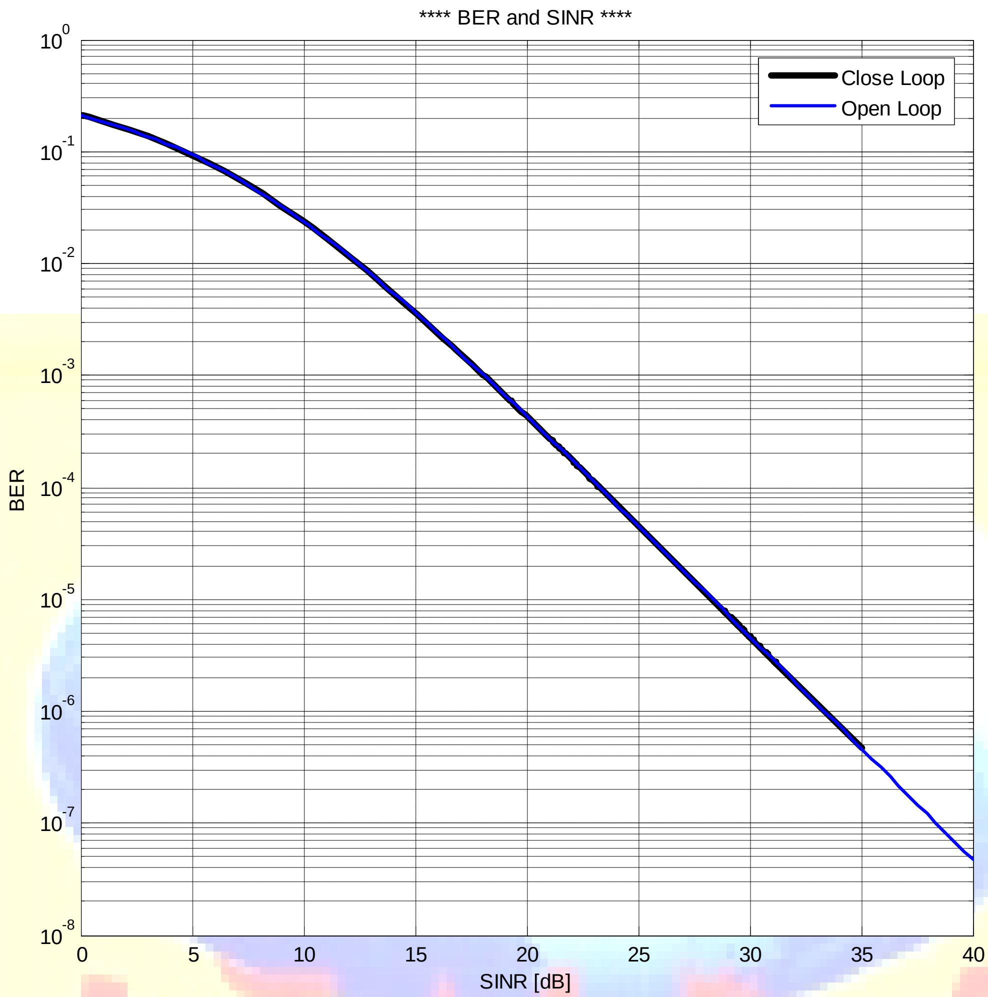


Figure 6: The BER performance for CLPC and OLPC.

Figure 6 shows the BER performance versus SINR for both CLPC and OLPC. Results in figure 6 conclude that the BER performance for the CLPC (the sold black curve) gives closely same result as the OLPC (the sold blue curve). Generally the CLPC is outperform the OLPC, however, the CLPC is add more over head to the system and the power control procedures are required to be fast as possible in order to meet the required quality of service (QoS).

## VI. *Conclusion*

In this paper, the two different PC techniques have been investigated and the results are shown in different performance parameters such as BER, throughput, PSD, and path loss. For same amount of power and also for high values of SINR the CLPC outperform the OLPC in term of the throughput. In term of the BER the CLPC and OLPC are perform similarly. However, the CLPC is add more over head to the system and the power control procedures are required to be fast as possible in order to meet the required quality of service (QoS).

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