TSG-RAN Working Group1 meeting #3 **TSGR1#3(99)151**
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Agenda Item:

Source: **Panasonic (Matsushita Communication Industrial Co., Ltd.)**

Title: **Adaptive Step Power Control (ASPC)**

Document for:

Summary:

This contribution proposed a new power control method that is called Adaptive Step Power Control (ASPC). ASPC can achieve better performance under any conditions compared with the conventional fixed step size method without any extra overhead.
We suppose that it is effective not only for general power control but also for slotted mode very much.

1. Introduction:

CDMA system requires power control to ensure its capacity, and the accuracy of the power control is very important. There are two kinds of power control. One is "open loop" and the other one is "closed loop". ”Closed loop” does have better performance. However, the “closed loop” power control requires feedback control data from the receiver side. In order to reduce this overhead, we may use only one bit for the power control data in each slot.

Because the power control data is only one bit, the conventional transmitter can only adjust its transmitting power level up or down by a fixed step size. However, as every body may have known, different channel situation may require different step size. In a high-changing speed channel environment, the step size must be large, correspondingly, the step size must be small in a low changing speed of channel environment. We also expect that it is very useful for slotted mode. Since during slotted mode, no power control can be done, error of power control is very much and after the mode finished, it should be compensate as soon as possible. ASPC can compensate quickly that control error and it leads saving of the excess power or relief of signal quality.

In this contribution, we propose a new power control method which is called Adaptive Step Power Control (ASPC). In this method, the power control data is still a single symbol. The up or down of the transmitting power level follows the sign of the symbol, and the step size is represented by the ratio of the amplitudes between the power control data symbol and pilot symbol. By using this power control method, the performance is improved without increasing the overhead. More detailed description of ASPC and the related simulation results are shown in the following:

We can show the BER performance on several conditions. The results shows that the performance of ASPC is very good on low noise condition and is not bad even on high noise condition.

We assume that ASPC is very usuful for slotted mode.

2. Detailed Description

2.1 General Description of ASPC

ASPC (Adaptive Step Power Control) is a method that can change the step size adaptively by amplitude modulation for the power control data symbol without increase of the overhead. A receiver can send the step size to a transmitter in which the step size is represented by the ratio of amplitude between the power control data symbol and pilot symbol. When a transmitter receives the power control data symbol, the transmitter will change its transmission power up or down according to the sign of the symbol with a proper step size which is decided by the ratio of the amplitude between the power control data symbol and pilot symbol. Further more, for large step size, the amplitude of power control data symbol must be larger than the pilot symbol. Correspondingly, for small step size, the amplitude of power control data symbol will be smaller than the pilot symbol.

We understand that smaller amplitude of the power control data may lead to the high error rate of the power control data. However, the influence of the error may be limited because the step size is small, and the small step size should only be used in the situation where the channel changing speed is low.

Fig 1 shows the signal forms transmitted from a receiver to a transmitter with both the conventional method and the new proposed method. In this figure, TPC is the power control data, PL is pilot and DATA are information bits. The amplitude ratio of PL and TPC in the conventional method is always kept the same, but they are not the same in the new proposed method.

Fig 2 shows the diagram of transmission power control block. a) is the conventional and b) is the proposed.

We used a function which convert step size to the ratio of TPC and PL as the equation (1).

$$X = \sqrt{LIM\{10 \times \log_{10}(RXC / RQC)\}}$$
$$RA = |X|$$
$$TPX = \operatorname{sgn}(X) \qquad \operatorname{sgn}(x) = \begin{cases} 1 & ; \; x > 0 \\ -1 & ; \; x < 0 \end{cases} \qquad \text{---------------------------(1)}$$

here, RXC is measured SIR of received signal, RQC is the target SIR, LIM is a limitter function and it clips the value of argument over the threshold which is a parameter of this function, RA is amplitude ratio of TPC and PL, and TPX is the sign of TPC bit. At the receiver, step size of power control may be square of demodulated RA. It should be limited with the same threshold as the transmitter. The reason which we use square function in the equation (1) is that we don't want to have large dynamic range and the reason which we use limitter is to suppress the over control caused by noise.

In the equation (1), X=0 can be used. It means that no power control should be done. When the transmission channel is in static state, X should be 0. The minimum step of transmission power control depends on the accuracy of amplifire control.

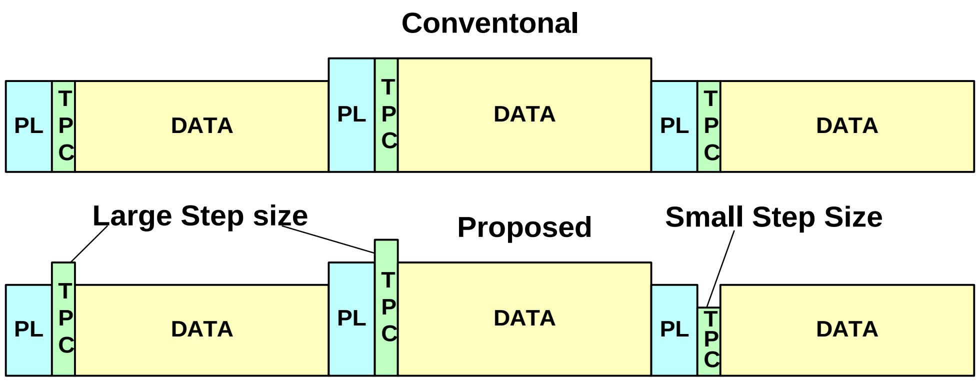
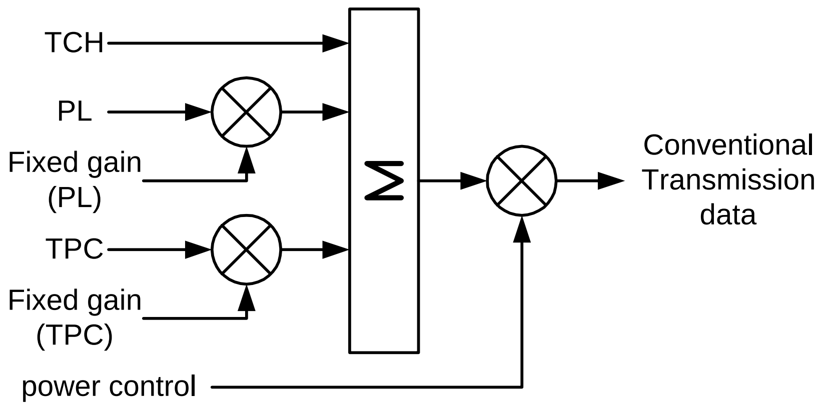
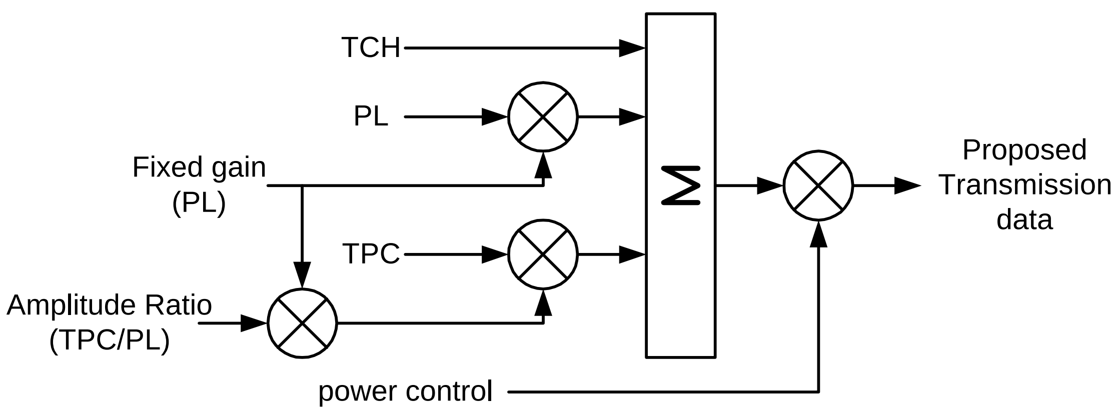


Fig 1 Signal forms transmitted from a receiver to a transmitter



a) Conventional



b) Proposed

Fig 2 Diagram of a transmission block

2.2 Performance of ASPC

We confirmed the performance of ASPC by computer simulation. The following Table 1 shows the parameters used in the simulation. In this simulation, we assume that the power control of uplink signal is ideal. Therefore, we set the characteristics of uplink signal to that of static channel. The definition of Eb/No, which is the horizontal axis of figures, is not consider the channel coding. When uplink Eb/No is -1.6dB, the error rate of TPC is about 12% for conventional method and much more for ASPC. The reason why the error rate of TPC for ASPC is larger than that of conventional method is that amplitude of TPC changes from 0 to RA. The error rate of that is different by channel condition. When uplink Eb/No is 11.1dB, the error rate of TPC is almost 0 for conventional method but 0.3 to 1.5% for that of ASPC.

Table 1 simulation parameter

Modulation	QPSK (roll off factor = 0.5)	Spreading factor of data	256
		Channel coding	NOT USED
Chip rate	4.096Mcps	Channel estimation	Ideal
Power control delay	1.25ms (2Slots)	Maximum Doppler freq.	10,40,100,200[Hz]
SIR estimation	Ideal	Channel propagation	1path, 2path

Fig.3 to Fig.18 are the result of the simulation. Table 2 shows details of their condition. This simulation, uplink signal is perfectly power controlled. Therefore, when uplink Eb/No is 11.1dB, TPC of conventional method in uplink has no error. However, even when uplink Eb/No is 11.1B, TPC of ASPC in uplink has several errors. The error rate is different by each condition.

Table 2 Condition of each figure

Figure number	fD[Hz]	Uplink Eb/No[dB]	Number of path
3	10	11.1	1
4	40	11.1	1
5	100	11.1	1
6	200	11.1	1
7	10	11.1	2
8	40	11.1	2
9	100	11.1	2
10	200	11.1	2
11	10	-1.6	1
12	40	-1.6	1
13	100	-1.6	1
14	200	-1.6	1
15	10	-1.6	2
16	40	-1.6	2
17	100	-1.6	2
18	200	-1.6	2

These figure shows that ASPC works very good for low noise condition (Eb/No=11.1dB). Especially, the condition of fD=10Hz or 40Hz, remarkable improvement of BER performance is observed. When the control delay is 1.25ms, it is difficult to follow fast channel which changing speed is over 100km/s. Even if ideal power control (IPC), when fD is high, not so much effect is provided. From Fig.11 to 18, we found that ASPC can also work under high noise condition and BER performance with ASPC doesn't be bad. Limitation is important and the threshold value of 3 is the best value.

There are many users in a cell and the velocity of them are different. Therefore, even if the effect of ASPC is small for high speed users, total performance will be good if that of ASPC is large for low speed users.

The function which used in ASPC will be optimized, but the result by eqation (1) shows already enough performance.

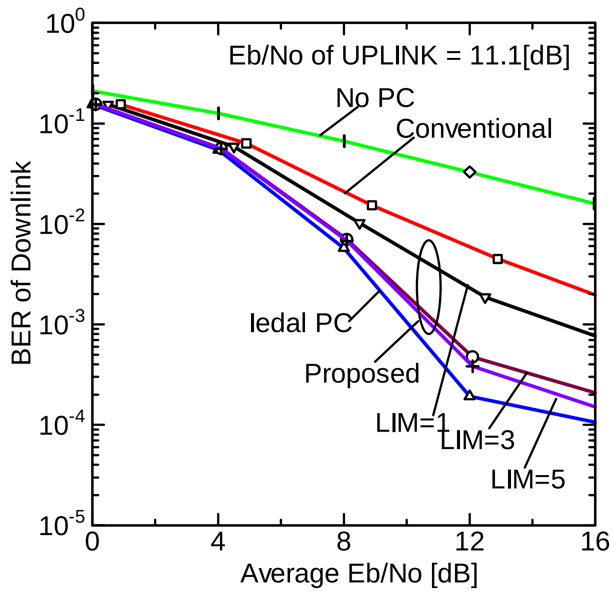


Fig 3 Performance of ASPC on fD=10Hz,1path,uplink Eb/No=11.1dB

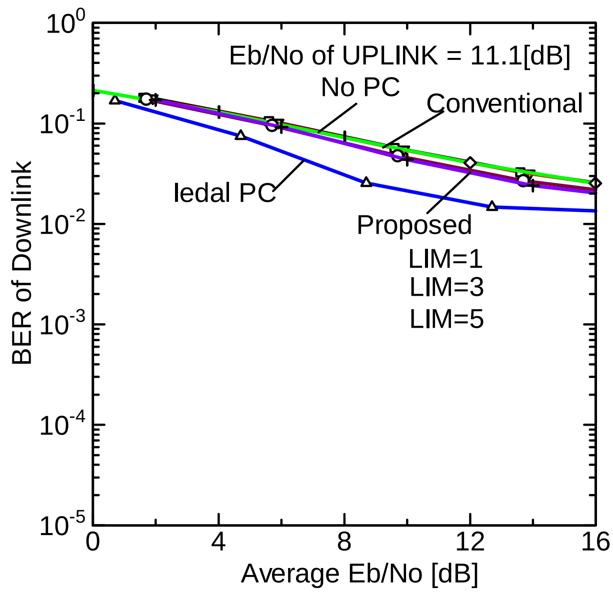


Fig 5 Performance of ASPC on fD=100Hz,1path,uplink Eb/No=11.1dB

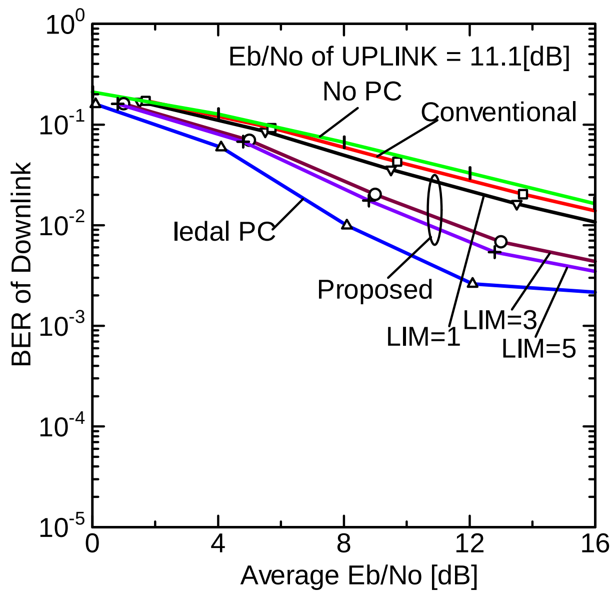


Fig 4 Performance of ASPC on fD=40Hz,1path,uplink Eb/No=11.1dB

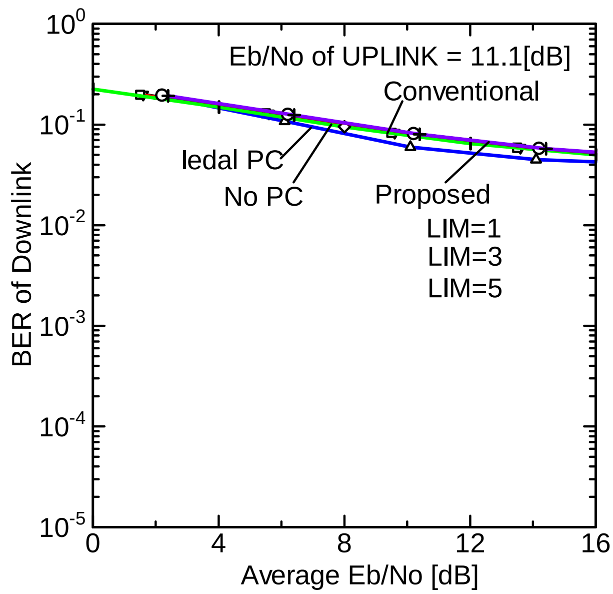


Fig 6 Performance of ASPC on fD=200Hz,1path,uplink Eb/No=11.1dB

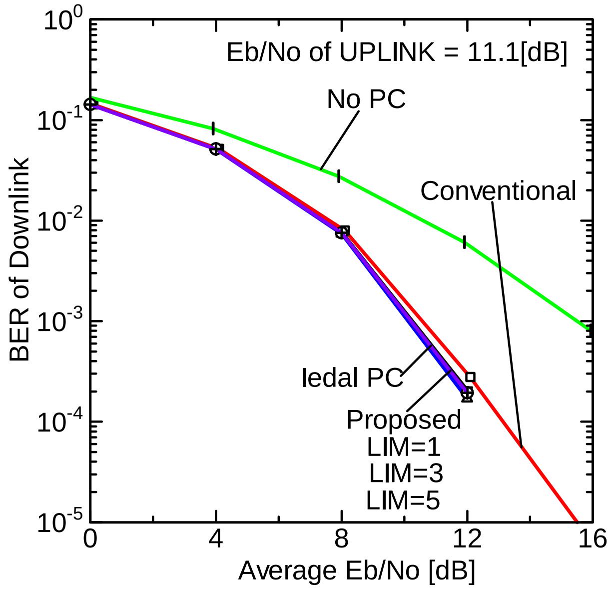


Fig 7 Performance of ASPC on fD=10Hz,2path,uplink Eb/No=11.1dB

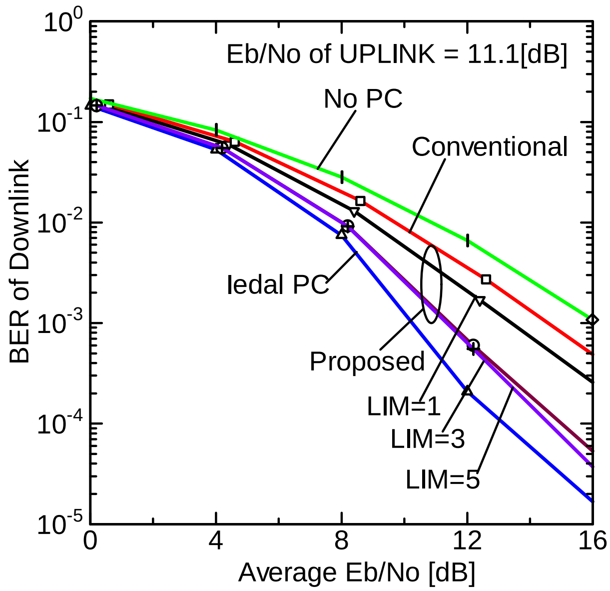


Fig 8 Performance of ASPC on fD=40Hz,2path,uplink Eb/No=11.1dB

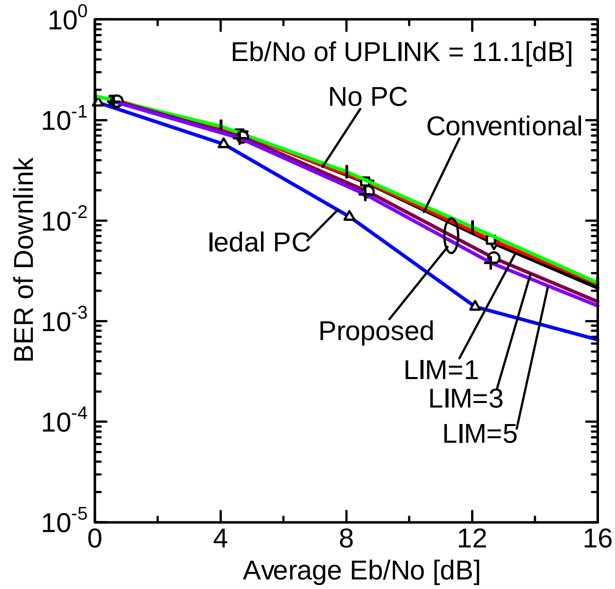


Fig 9 Performance of ASPC on fD=100Hz,2path,uplink Eb/No=11.1dB

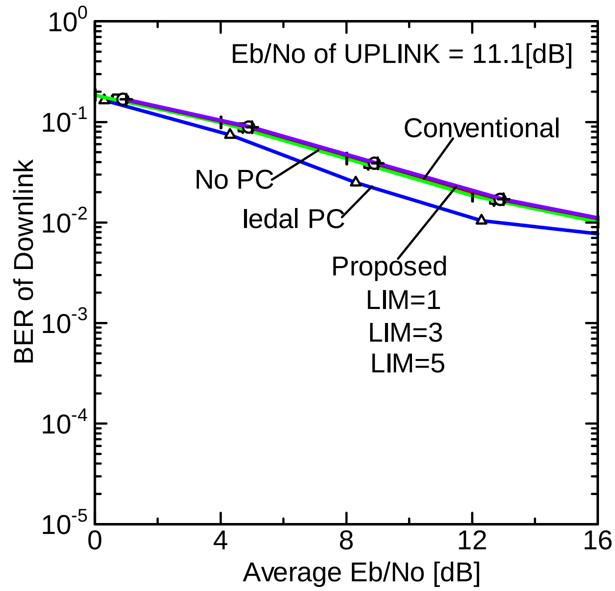


Fig 10 Performance of ASPC on fD=200Hz,2path,uplink Eb/No=11.1dB

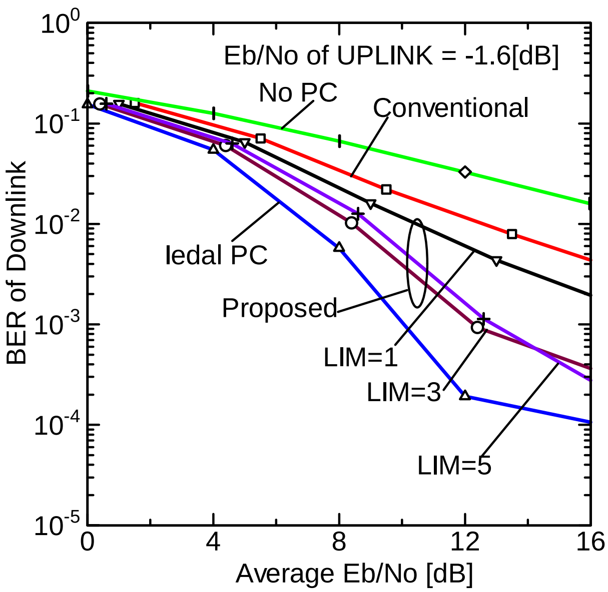


Fig 11 Performance of ASPC on fD=10Hz,1path,uplink Eb/No= -1.6dB

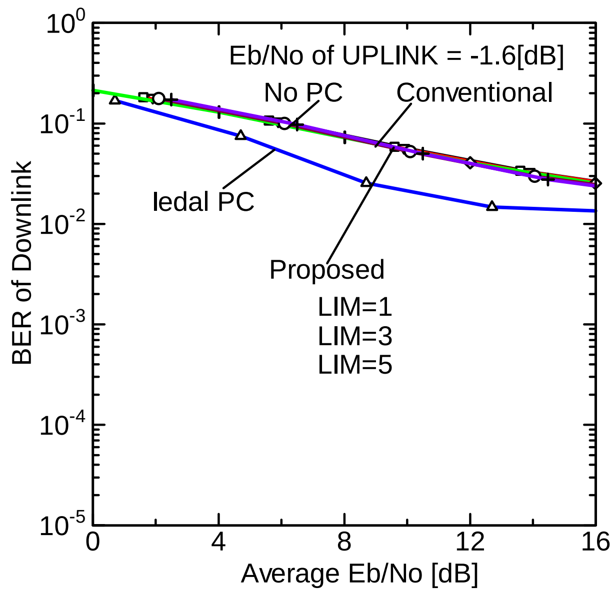


Fig 13 Performance of ASPC on fD=100Hz,1path,uplink Eb/No= -1.6dB

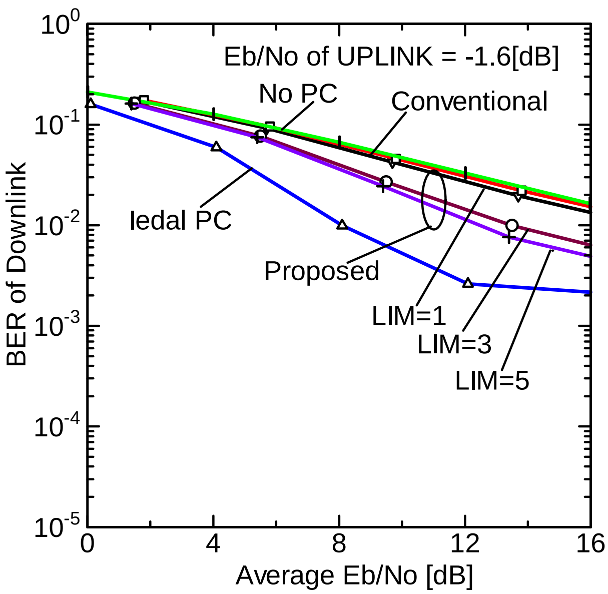


Fig 12 Performance of ASPC on fD=40Hz,1path,uplink Eb/No= -1.6dB

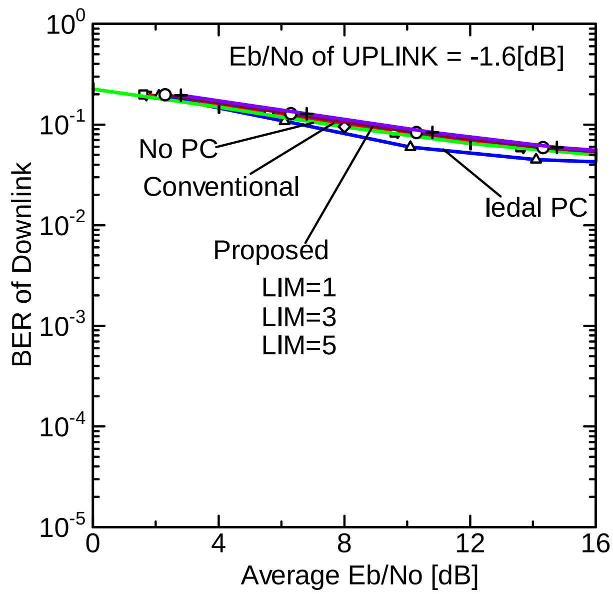


Fig 14 Performance of ASPC on fD=200Hz,1path,uplink Eb/No= -1.6dB

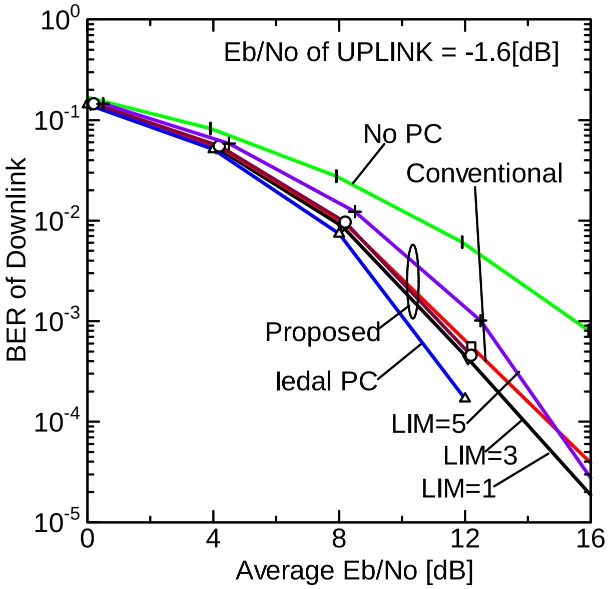


Fig 15 Performance of ASPC on fD=10Hz,2path,uplink Eb/No= -1.6dB

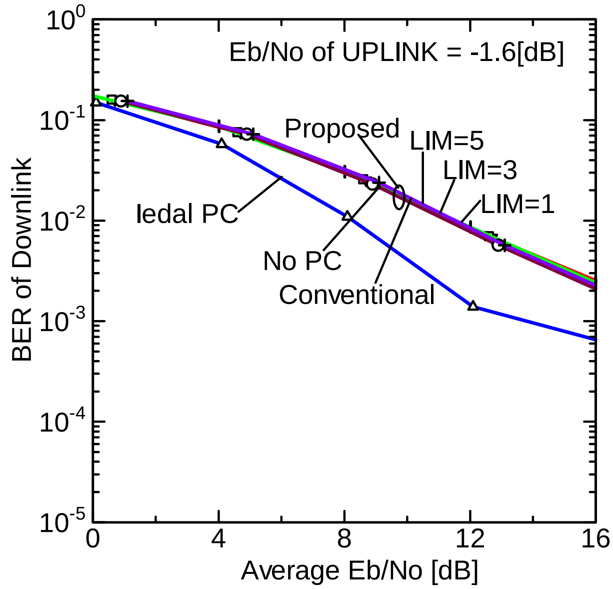


Fig 17 Performance of ASPC on fD=100Hz,2path,uplink Eb/No= -1.6dB

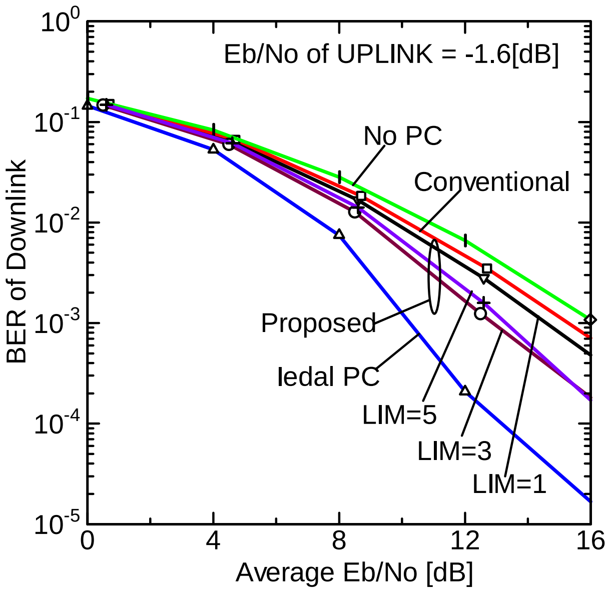


Fig 16 Performance of ASPC on fD=40Hz,2path,uplink Eb/No= -1.6dB

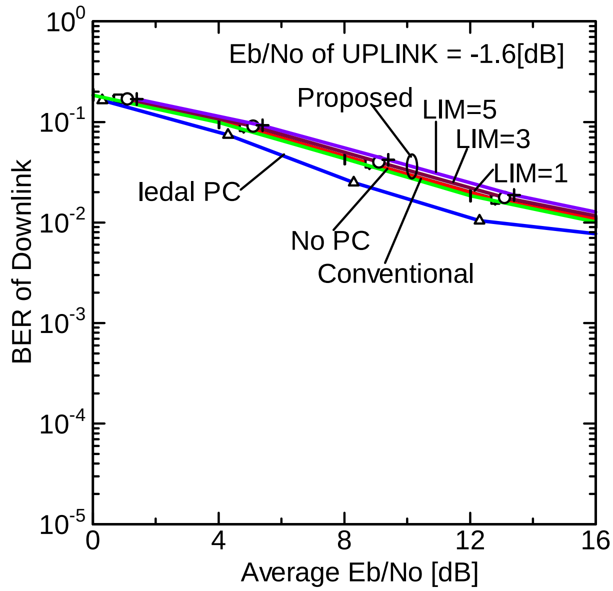


Fig 18 Performance of ASPC on fD=200Hz,2path,uplink Eb/No= -1.6dB

2.3 Application of ASPC for Slotted Mode

We suppose that ASPC is very effective for "slotted mode". When a system is under slotted mode, TPC command can not be used. Therefore, transmission power should not be changed. Fig 19 shows the effect of ASPC under slotted mode. Fixed step control requires long convergence time for much control error after slotted mode. However, ASPC requires short convergence time. It is very usuful for much error but also good even if the control error is not so much. The case of Fig 19 shows that duration of too much interference occurs for long time with fixed step control, but short time with ASPC. On the other hand, the case of Fig 20 shows that duration of very low signal quality occurs for long time with fixed step control, but short time with ASPC. Fig 19 and Fig 20 show that ASPC can realize no power control during not slotted mode. It is easy to realize by zero amplitude for TPC.

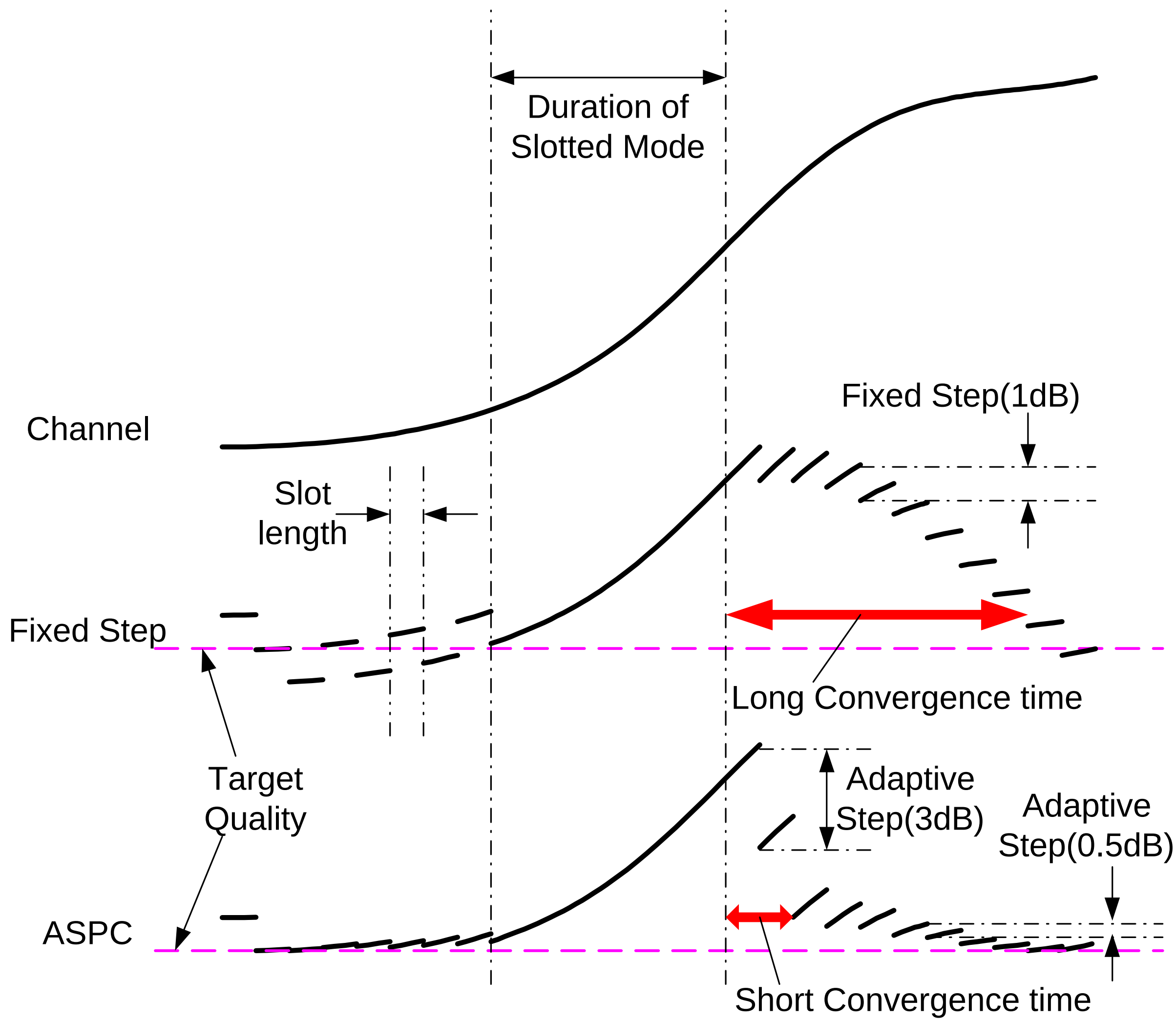


Fig 19 Effect of ASPC under Slotted Mode when much interference occurs

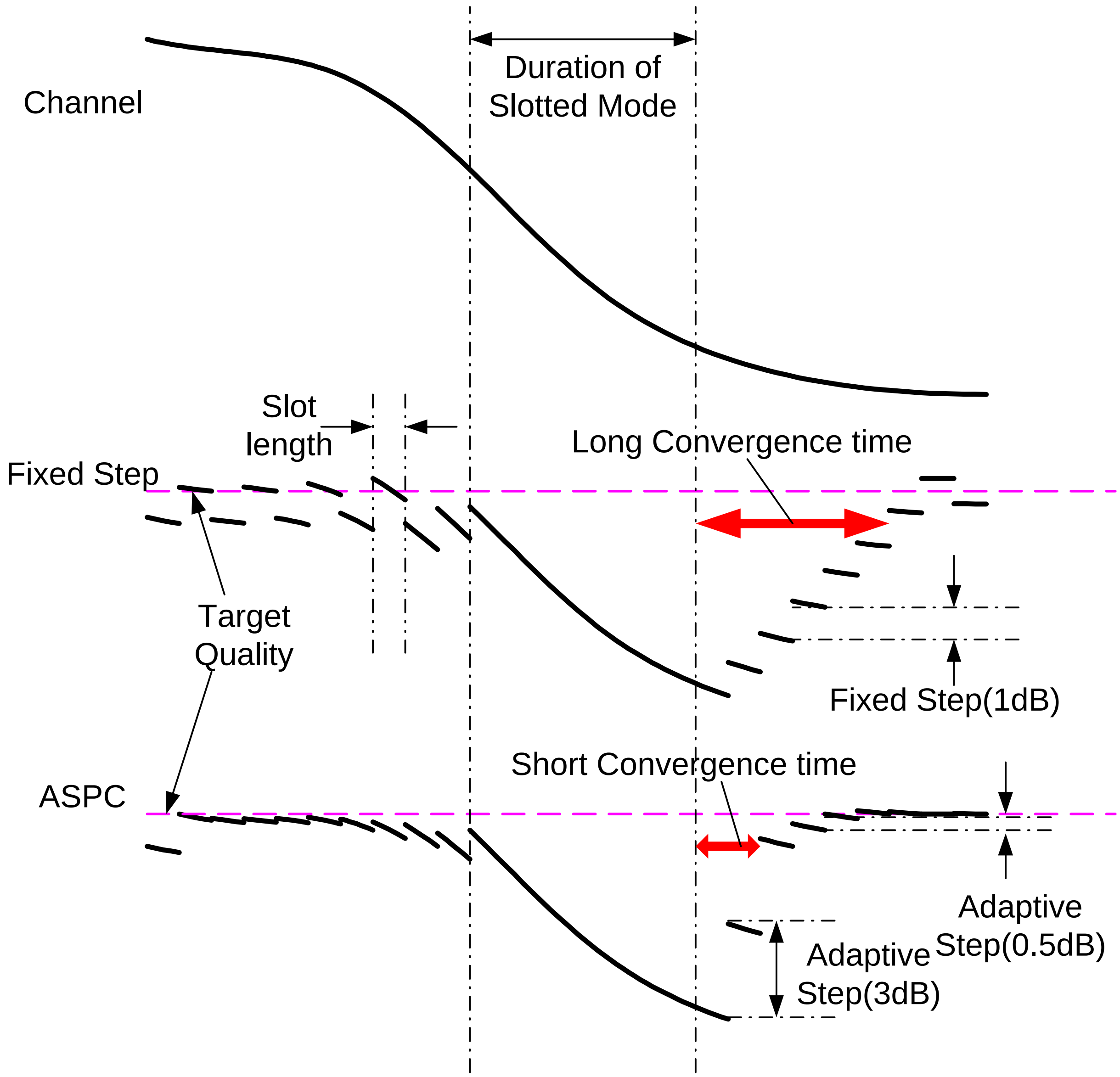


Fig 20 Effect of ASPC under Slotted Mode when the signal quality is very low

3. Conclusion

This proposed new power control method, named as ASPC (Adaptive Step Power Control), can achieve better performance under any conditions compared with the conventional fixed step size method without any extra overhead. The reasonable limitation value of step size (V) is 3dB which effects not much damage for transmission power amplifier and not large degradation of the performance of ASPC. We confirmed that ASPC can work well under even small Eb/No condition.

ASPC can be introduced for slotted mode and when ASPC is used, convergence time of power control will be short. It is very useful and not complex to introduce.

The function which used in ASPC will be optimized, but the result by eqation (1) shows already enough performance.

Simulation results of this paper is dounlink performance. However, that of uplink must be the same.