TSG-RAN Working Group 1 meeting #7
Hannover, Germany, Aug. 30 - Sep. 3, 1999

TSGR1#7(99)c62

Agenda Item:

Source: **SK Telecom**

Title: **Power Control Scheme with Adaptive Step**

Document for: **Discussion**

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1. Introduction

In this document, we propose the new power control schemes with adaptive step size and present the simulation results. In [1], we proposed the basic idea of the scheme and presented the preliminary simulation results. In this proposal, we add three more schemes and present the link level simulation results compared with other proposed schemes.

2. Detailed Algorithm

In the proposed power control scheme, the transmit power is determined by the following equation:

$$P_n = P_{n-1} + TPC \cdot N' \cdot \Delta P$$

where

P_n	Current transmit power
P_{n-1}	Previous transmit power
TPC	Sign of TPC bit (± 1)
N'	$= \min(N, \Delta P_{\max} / \Delta P)$
N	Number of the step (determined by the methods in section 2.1)
$\Delta P_{\max}$	Maximum increament
ΔP	Step size

2.1 Methods of determining N

Method 1)

If the sign of the current TPC bit is the same as the previous one (i.e., in the case of monotonic increasing (or decreasing)), $N=N+1$.

Otherwise, $N = N-1$.

Method 2)

If the sign of the current TPC bit is the same as the previous one (i.e., in the case of monotonic increasing (or decreasing)), $N=N+1$.

If the sign of the previous one is +1 (i.e., increasing) and the current one is –1 (i.e., decreasing), then $N = N-1$.

If the sign of the previous one is -1 (i.e., decreasing) and the current one is +1 (i.e., increasing), then $N = 1$.

Method 3)

If the sign of the current TPC bit is the same as the previous one and the TPC bit is +1 (i.e., in the case of monotonic increasing), $N=N+1$.

If the sign of the current TPC bit is the same as the previous one and the TPC bit is -1 (i.e., in the case of monotonic decreasing), $N=N-1$.

If the sign of the previous one is +1 (i.e., increasing) and the current one is –1 (i.e., decreasing), then $N = N-1$.

If the sign of the previous one is -1 (i.e., decreasing) and the current one is +1 (i.e., increasing), then $N = 1$.

Method 4)

If the sign of the current TPC bit is the same as the previous one and the TPC bit is +1 (i.e., in the case of monotonic increasing), $N=N+1$.

If the sign of the current TPC bit is the same as the previous one and the TPC bit is -1 (i.e., in the case of monotonic decreasing), *N=N-1*.
If the sign of the previous one is +1 (i.e., increasing) and the current one is –1 (i.e., decreasing), then $N = N$.
If the sign of the previous one is -1 (i.e., decreasing) and the current one is +1 (i.e., increasing), then $N = 1$.

Method 5)
If the sign of the current TPC bit is the same as the previous one and the TPC bit is +1 (i.e., in the case of monotonic increasing), *N=N+1*.
If the sign of the current TPC bit is the same as the previous one and the TPC bit is -1 (i.e., in the case of monotonic decreasing), *N=N+1*.
If the sign of the previous one is +1 (i.e., increasing) and the current one is –1 (i.e., decreasing), then $N = 1$.
If the sign of the previous one is -1 (i.e., decreasing) and the current one is +1 (i.e., increasing), then $N = 1$.

We must note that N is equal to or greater than 1 in the above methods. These 5 methods are summarised in Table 1 below and Figure 1 briefly shows the difference between the methods in diagram.

Table 1 Summary of proposed 5 methods

Pattern of TPC bits change (Previous TPC → Current TPC)	Method 1	Method 2	Method 3	Method 4	Method 5
+ → +	*N=N+1*	*N=N+1*	*N=N+1*	*N=N+1*	*N=N+1*
- → -	*N=N+1*	*N=N+1*	*N=N-1*	*N=N-1*	*N=N+1*
+ → -	*N=N-1*	*N=N-1*	*N=N-1*	*N=N*	*N=1*
- → +	*N=N-1*	*N=1*	*N=1*	*N=1*	*N=1*

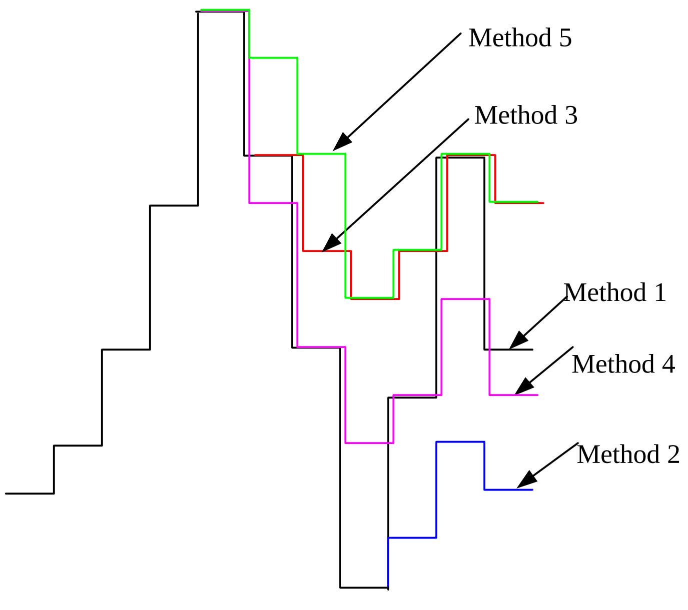


Figure 1 Comparison of proposed 5 methods

In the above figure, we assume that the change patterns of TPC command bits for all four methods are the same each other. However practically the change patterns of TPC bits may be different from each other.

3. Simulation Results
3.1 Simulation Conditions

Table 2 System Model for Simulation

System Model		
Carrier Frequency		2 [GHz]
Chip Rate		3.84 [Mcps]
Frame Size		10 [ms]
Number of Slot per Frame		15
Scrambling Code		Gold code
Modulation	Data	BPSK
	Spreading	HPSK
Samples/Chip		8 [spc]
Number of Antenna		2
Number of Fingers of RAKE Receiver		2 per Antenna
Phase Estimation		FIR filter with length (1 or 4)*10/15 [ms]
Power Control		Power control command bit rate = 1500 [Hz] Power control command bit error = 4 % Power control delay = 1 slot Power control step size = 0.25/0.5/1.0 [dB]
Physical Channel Type		15 [ksps] DPDCH 120 [ksps] DPDCH

Table 3 Channel Model for Simulation

Channel Model	
AWGN	Considered
Log-normal Shadowing	Not considered
Multipath Fading	ITU-R channel model (Ref.: M.1225): -Indoor A (Speed = 3[km/h], i.e., maximum Doppler frequency = 5.6[Hz]) -Outdoor to indoor and pedestrian A (Speed = 3[km/h], i.e., maximum Doppler frequency = 5.6[Hz]) -Vehicular A (Speed = 15, 30, 60, 120[km/h], i.e., maximum Doppler frequency = 222.2[Hz])
Rayleigh Fading	Generated using JTC model: Interpolation filter bandwidth = 1/(2Tc) Interpolation filter delay tap length = 12 Interpolation resolution = 0.1Tc Select 6 output points which have maximum average power

3.2 Simulation Cases and Results
For the comparison with conventional method and other two schemes proposed by Philips and Nortel, we summarise the schemes as follows:

Conventional PC Method

Emulated Step PC Method by Philips (R1-99959):

In order to determine the transmit power, the UE concatenates N consecutive commands, e.g. 3 commands or 5 commands, the power control size being 1 dB.

Nortel's Method (R1-99666):

The transmitter applies the normal power control step such that when it receives a TPC=0, then the power is decreased by and when it receives a TPC=1 then the power is increase by Δ1. If Y TPC commands among the last X commands, including the last received one (not yet applied), correspond to TPC=1, then the power step size is change to Δ2. If a transition between TPC=1 and TPC=0 is detected then the power is decreased by the power control step Δ3 in the next consecutive Z slots, irrespective to the power control command received.

Ex) Δ1=1 dB, Δ2=1 dB, Δ3=2 dB, X=10, Y=9, Z=1.

Table 4 shows the simulation cases for which we perform.

Table 4 Parameters for Simulation

System Model		**Radio Channel Model**							
Physical Channel (Uplink)	PC Algorithms	Indoor A	Outdoor to indoor and pedestrian A		Vehicular A	15	30	60	120
① DPDCH 15 [ksps] (SF=256)	Conventional PC (0.25, 0.5, 1.0 dB)	1Ci	1Co02	○	1Cv02	○	○	○	○
			1Co05		1Cv05				○
			1Co10	○	1Cv10	○	○	○	○
*② DPDCH 120 [ksps] (SF=32)	Emulated Step PC 3, 5 (1.0 dB)	1E3i	1E3o	○	1E3v	○	○	○	○
		1E5i	1E5o	○	1E5v	○	○	○	○
	Nortel APC (1.0 dB)	1Ni	1No	○	1Nv		○		○
	SKT PC1, 2, 3, 4, 5 (0.25, 0.5, 1.0 dB)	1S1i	1S1o02	○	1S1v02				○
		1S2i	1S1o05		1S1v05				○
		1S3i	1S1o10		1S1v10				○
			1S2o02	○	1S2v02				○
			1S2o05		1S2v05				○
			1S2o10		1S2v10				○
			1S3o02	○	1S3v02	○	○	○	○
			1S3o05		1S3v05				○
			1S3o10		1S3v10		○		○
			1S4o02	○	1S4v02		○	○	○
			1S4o05		1S4v05				
			1S4o10		1S4v10		○		
			1S5o02	○	1S5v02				
			1S5o05		1S5v05				
			1S5o10		1S5v10				

*②: not completed.

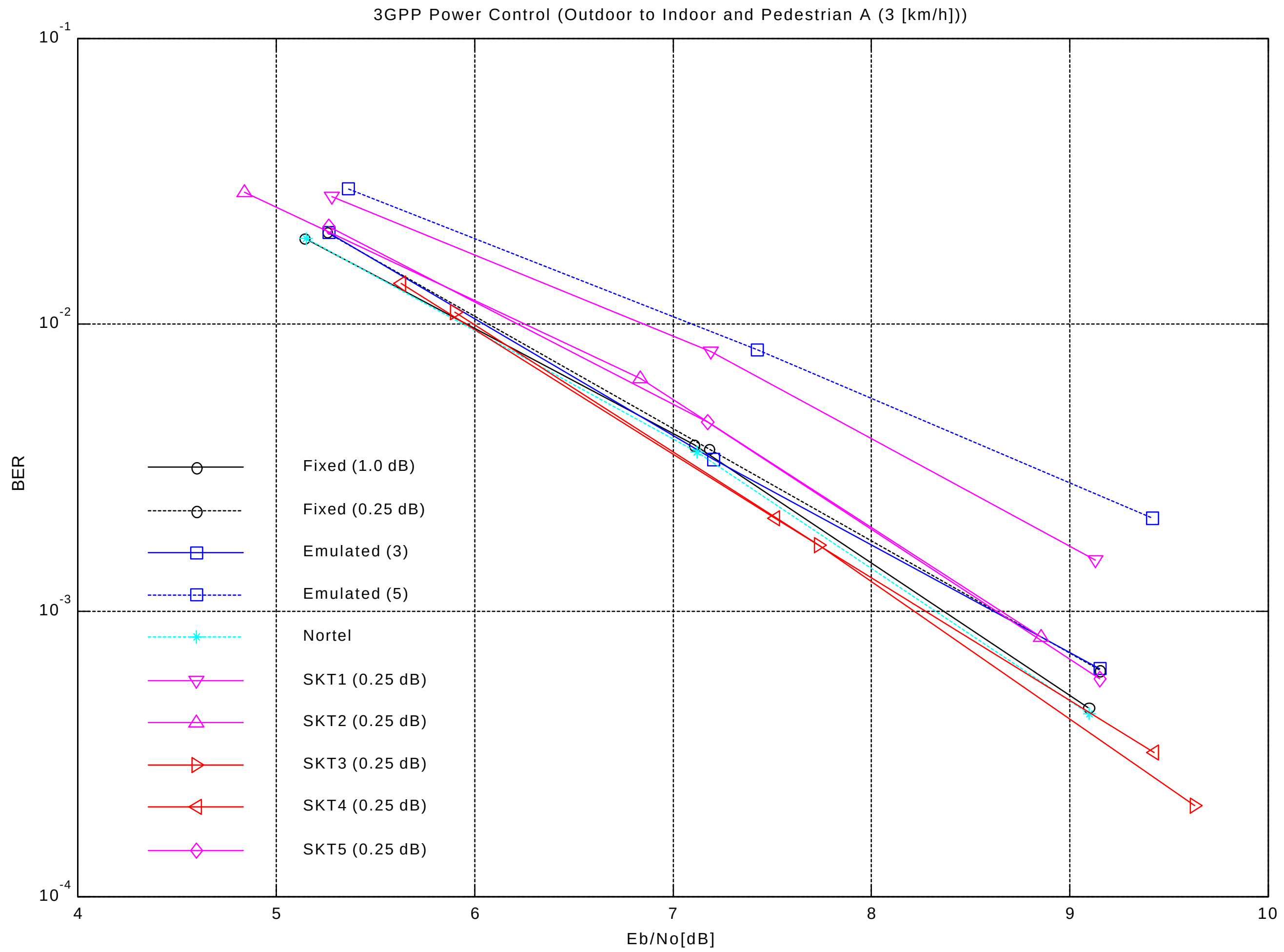
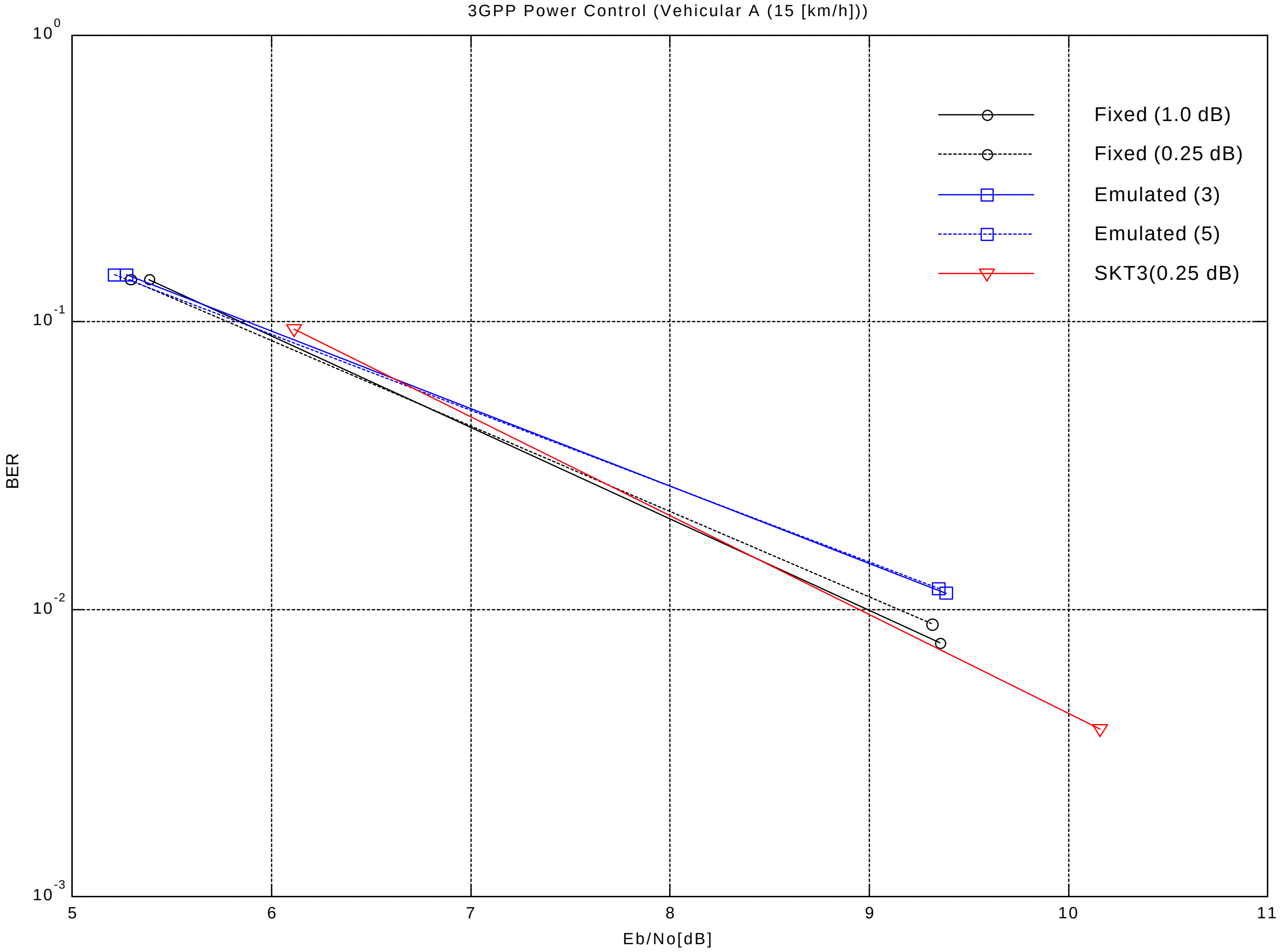

3GPP Power Control (Outdoor to Indoor and Pedestrian A (3 [km/h]))
BER
Eb/No[dB]
10^-1
10^-2
10^-3
10^-4
4
5
6
7
8
9
10
Fixed (1.0 dB)
Fixed (0.25 dB)
Emulated (3)
Emulated (5)
Nortel
SKT1 (0.25 dB)
SKT2 (0.25 dB)
SKT3 (0.25 dB)
SKT4 (0.25 dB)
SKT5 (0.25 dB)

Figure 2



3GPP Power Control (Vehicular A (15 [km/h]))
Fixed (1.0 dB)
Fixed (0.25 dB)
Emulated (3)
Emulated (5)
SKT3(0.25 dB)
BER
Eb/No[dB]

Figure 3

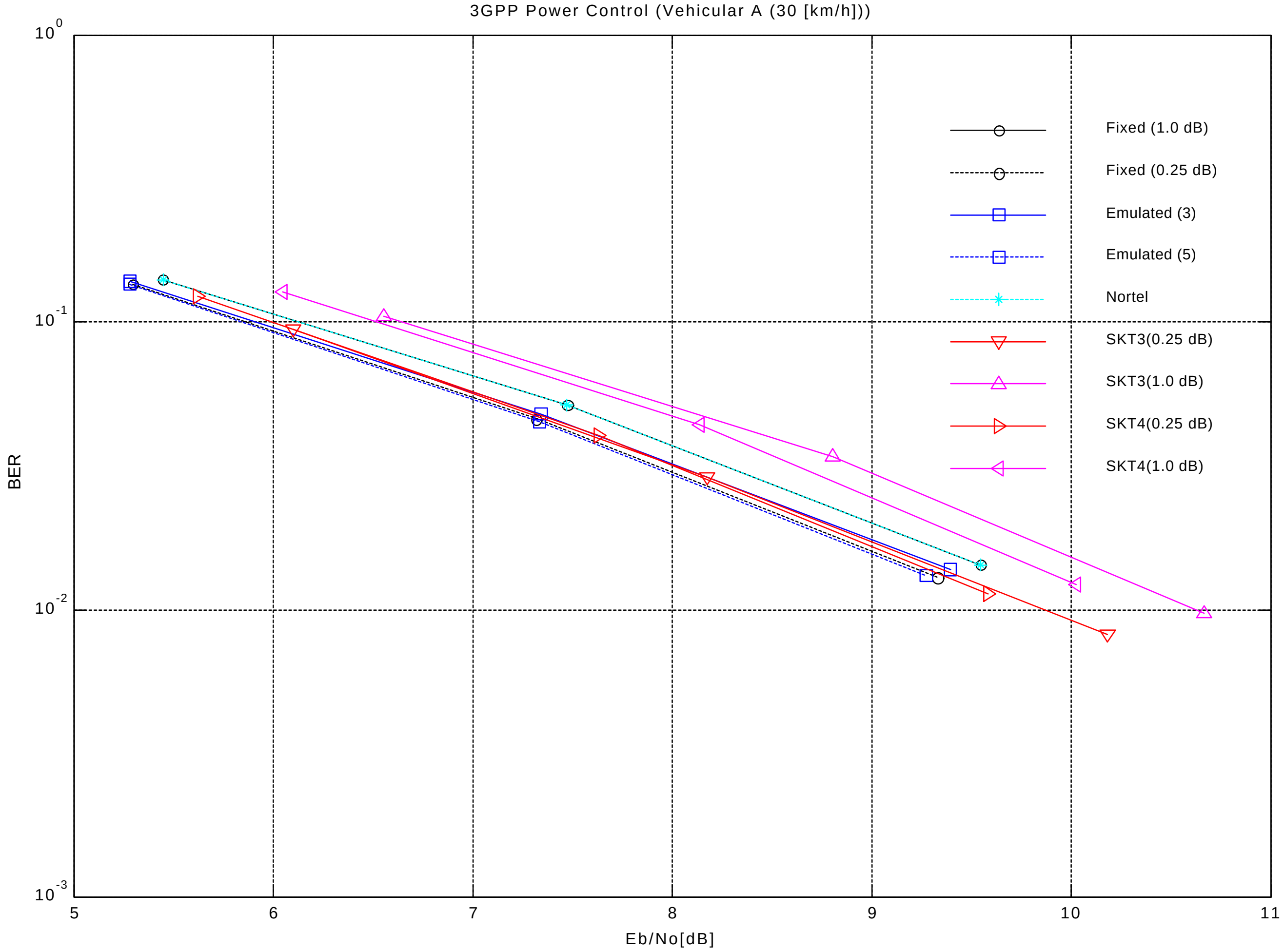

3GPP Power Control (Vehicular A (30 [km/h]))
BER
Eb/No[dB]
10^{0}
10^{-1}
10^{-2}
10^{-3}
5
6
7
8
9
10
11
Fixed (1.0 dB)
Fixed (0.25 dB)
Emulated (3)
Emulated (5)
Nortel
SKT3(0.25 dB)
SKT3(1.0 dB)
SKT4(0.25 dB)
SKT4(1.0 dB)

Figure 4

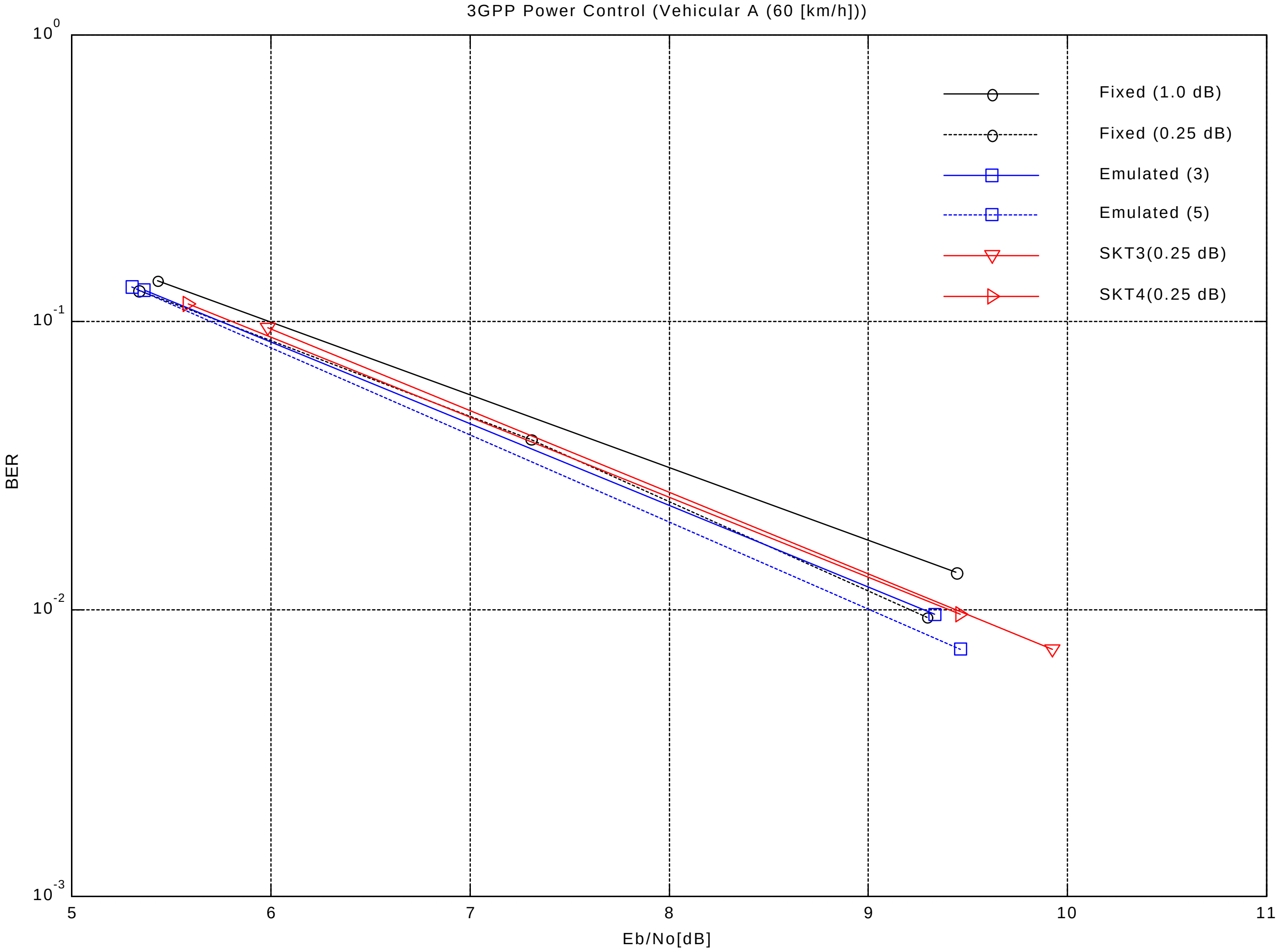

3GPP Power Control (Vehicular A (60 [km/h]))
Fixed (1.0 dB)
Fixed (0.25 dB)
Emulated (3)
Emulated (5)
SKT3(0.25 dB)
SKT4(0.25 dB)
BER
Eb/No[dB]
10^0
10^-1
10^-2
10^-3
5
6
7
8
9
10
11

Figure 5

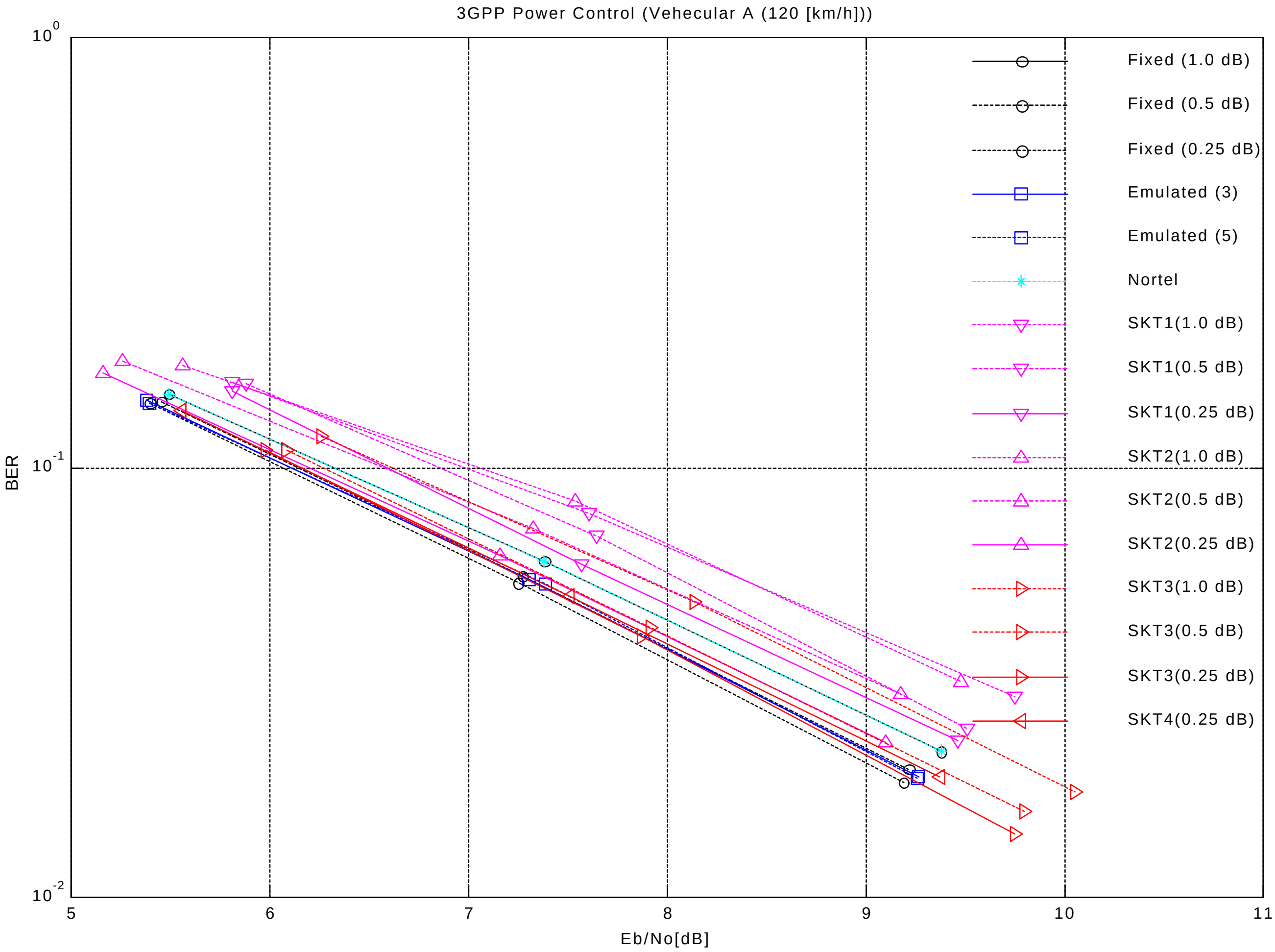

3GPP Power Control (Vehecular A (120 [km/h]))
BER
Eb/No[dB]
10^0
10^-1
10^-2
5
6
7
8
9
10
11
Fixed (1.0 dB)
Fixed (0.5 dB)
Fixed (0.25 dB)
Emulated (3)
Emulated (5)
Nortel
SKT1(1.0 dB)
SKT1(0.5 dB)
SKT1(0.25 dB)
SKT2(1.0 dB)
SKT2(0.5 dB)
SKT2(0.25 dB)
SKT3(1.0 dB)
SKT3(0.5 dB)
SKT3(0.25 dB)
SKT4(0.25 dB)

Figure 6

4 Conclusions

The results presented in this paper show that the proposed power control methods with step size of 0.25 dB can give performance better than the any other schemes in some scenarios, especially low speeds. At very high speed, the results show that the proposed adaptive scheme with step size of 0.25 dB can give performance similar to or better than the other schemes.

We therefore propose the minimum step size of 0.25 dB to be mandatory and multiple steps of 0.25 dB optional. We also propose the 3rd power control scheme of SK Telecom is used in the normal mode.

5 References

[1] TSGR1#6(99)989 *"Power Control Scheme Adaptive to Channel Variation"*, SK Telecom, July 1999.