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Espoo, Finland

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Document for: Discussion and approval

Summary:

TBA

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1. INTRODUCTION

In the TSG-R WG1 meeting #5 the Tx diversity closed loop modes were unified in that they all are based on Tx AA concept [1]. In order to simplify the closed loop operation and to improve the performance a slight modification to the Tx AA basic solution is proposed.

2. REFINED TX AA MODES

2.1 Existing closed loop solution

All the closed loop modes are based on Tx AA technique. Table 1 list some parameters describing the modes. Note that by using 2 FBI bits per slot feedback bit rate can be increased to 3.2 kbps resulting also in 2 times higher update rate for modes 2 and 3. Thus a total of 5 modes exist in the current concept.

Table 1. N_{FBI}, N_W, *update rate, feedback bit rate and number of power and phase bits per signaling word for different feedback modes. Chip rate of 4.096 Mchip/s is assumed.*

FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
1	1	1	1600 Hz	1600 bps	0	1
2	1	2	800 Hz	1600 bps	0	2
3	1	4	400 Hz	1600 bps	1	3
4	2	1	1600 Hz	3200 bps	0	2
5	2	2	800 Hz	3200 bps	1	3

One justification for such a high number of different modes has been that for each mode there is a radio environment where that mode provides the best performance. Yet, from conceptual and implementation point of view it would be best to have as few modes as possible. Based on extensive number of simulations it seems that we, indeed, don't need so many different modes. Number of modes can be reduced by introducing slight modification to the closed loop solution. What is even better, in some cases we can also improve the performance when compared to current solution.

2.2 Refined closed loop solution

In the refined Tx AA concept the different quantizations of the constellation used by Node B to transmit the signal from the two antennas is achieved by introducing constellation rotation at UE and filtering the weights at Node B. This can be generalized as:

$$f_{Tx}[n] = f(f_{Rx}[n]) \tag{1}$$

where f_{Tx} is the phase difference between antennas at transmit side as used by Node B and f_{Rx} refer to phase (weight) received by Node B from UE. Filter, $f()$, may be FIR, IIR, non-linear etc filter in general. Different feedback modes are then characterized by the filter and possible values of f_{Rx}. Values of the f_{Rx} depends on how the received signal from antenna 1 (non-diversity antenna) is rotated at the UE before solving for the optimum weight to be used at transmit side. When combined with filtering of the received weights at Node B we effectively speaking increase the number of possible constellation points, yet the feedback command rate can be kept high. This improves the performance and extents the application range of a mode towards higher UE speeds.

2.2.1 Refined feedback mode 1

This is the same as the current mode 1. In order to enable channel estimation from Common Pilot Channel (CPiCH) and verification at UE, different dedicated pilot pattern is employed based on the actual phase difference used by Node B between the transmit antennas. Correspondence between the feedback command and the phase difference between the transmit antennas is shown in the Table 2. No filtering of the feedback weights is performed in Node B. Correspondingly, no constellation rotation is done at UE. Table 3 shows the basic parameters of the mode assuming 15 slots per frame.

Table 2. Feedback command and corresponding phase difference.

Value	f_{Rx}
0	0
1	180

Table 3. N_{FBI}, N_W, *update rate, feedback bit rate and number of power and phase bits per signaling word for refined feedback mode 1. Chip rate of 3.84 Mchip/s is assumed.*

Refined FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
1	1	1	1500 Hz	1500 bps	0	1

2.2.2 Refined feedback mode 2

From UE point of view feedback mode 2 is same as mode 1 except that the signal received from antenna 1 is rotated by $N\frac{p}{4} \bmod 2p$ so that we get:

$$f_{Tx}[n] = \frac{1}{4}\sum_{i=0}^{3} f_{Rx}[n-i] \qquad (2)$$

where,

$$\begin{aligned} &f_{Rx}[0] \in \{0, p\} \\ &f_{Rx}[i] \in \left\{\{f_{Rx}[i-1]\} + p/4 \bmod 2p\right\} \end{aligned} \qquad (3)$$

The feedback command rate is the same as in mode 1. Mapping between feedback commands and phase difference between transmit antennas for 4 consecutive slots is shown in the Table 4. Basic parameters describing the refined mode 2 are listed in the Table 5.

Table 4. Feedback command and corresponding phase differences.

Value	f_{Rx}			
	Slot i	Slot i+1	Slot i+2	Slot i+3
0	0	45	90	135
1	180	-135	-90	-45

Table 5. N_{FBI}, N_W, *update rate, feedback bit rate and number of power and phase bits per signaling word for refined feedback mode 2. Chip rate of 3.84 Mchip/s is assumed.*

Refined FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
2	1	1	1500 Hz	1500 bps	0	1

2.2.3 Refined feedback mode 3

Refined feedback mode 3 is similar to current FB mode 3 in that UE quantizes the phase difference into QPSK constellation. However, no amplitude weighting is used so unlike the current FB mode 3 the refined FB mode 3 is power balanced as all the other FB modes. Constellation is rotated by π/4 yielding:

$$f_{Tx}[n] = \frac{1}{2}\sum_{i=0}^{1} f_{Rx}[n-i] \qquad (4)$$

where,

$$\begin{aligned} f_{Rx}[0] &\in \left\{0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}\right\} \\ f_{Rx}[i] &\in \left\{\{f_{Rx}[i-1]\} + \pi/4 \ \mathrm{mod}\ 2\pi\right\} \end{aligned} \qquad (5)$$

Table 6. Feedback command and corresponding phase differences.

Value	f_{Rx}	
	Slot i	Slot i+1
00	180	-135
01	-90	-45
10	0	45
11	90	135

Table 7. N_{FBI}, N_W, *update rate, feedback bit rate and number of power and phase bits per signaling word for refined feedback mode 3. Chip rate of 3.84 Mchip/s is assumed.*

Refined FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
3	2	1	1500 Hz	3000 bps	0	2

2.3 Simulation results

One set of simulation results for existing modes, Tx AA1, Tx AA2, Tx AA3, Tx AA4 and Tx AA5 and refined feedback modes RTx AA 2 and RTx AA3 are depicted in Figures 1-6 of annex 1. Terminals speeds 3, 10 and 40 (42.3) km/h in single tap Rayleigh, Pedestrian A and Vehicular A channels have been used.

(Analysis of the results TBA).

2.4 Summary of refined FB modes

The characteristics of the three refined feedback modes can be summarized as in Table 8.

Table 8. N_{FBI}, N_W, *update rate, feedback bit rate and number of power and phase bits per signaling word for refined feedback modes. Chip rate of 3.84 Mchip/s is assumed.*

Refined FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}	Constellation rotation
1	1	1	1500 Hz	1500 bps	0	1	N/A
2	1	1	1500 Hz	1500 bps	0	1	$\pi/4$
3	2	1	1500 Hz	3000 bps	0	2	$\pi/4$

By adopting the refined FB modes we get the following benefits:

- Reduced number of modes
- Improved performance
- All the modes are power balanced
- Simplified UE operation
- Improved robustness from mode control point of view
  - ★ Less accurate doppler measurement needed as the application range of the modes overlap even more than earlier
- Feedback command rate equals to slot rate $\Rightarrow$ no slipping of commands over frame boundaries in case of 15 slots per frame

3. TEXT PROPOSAL

TBA

4. CONCLUSIONS

TBA

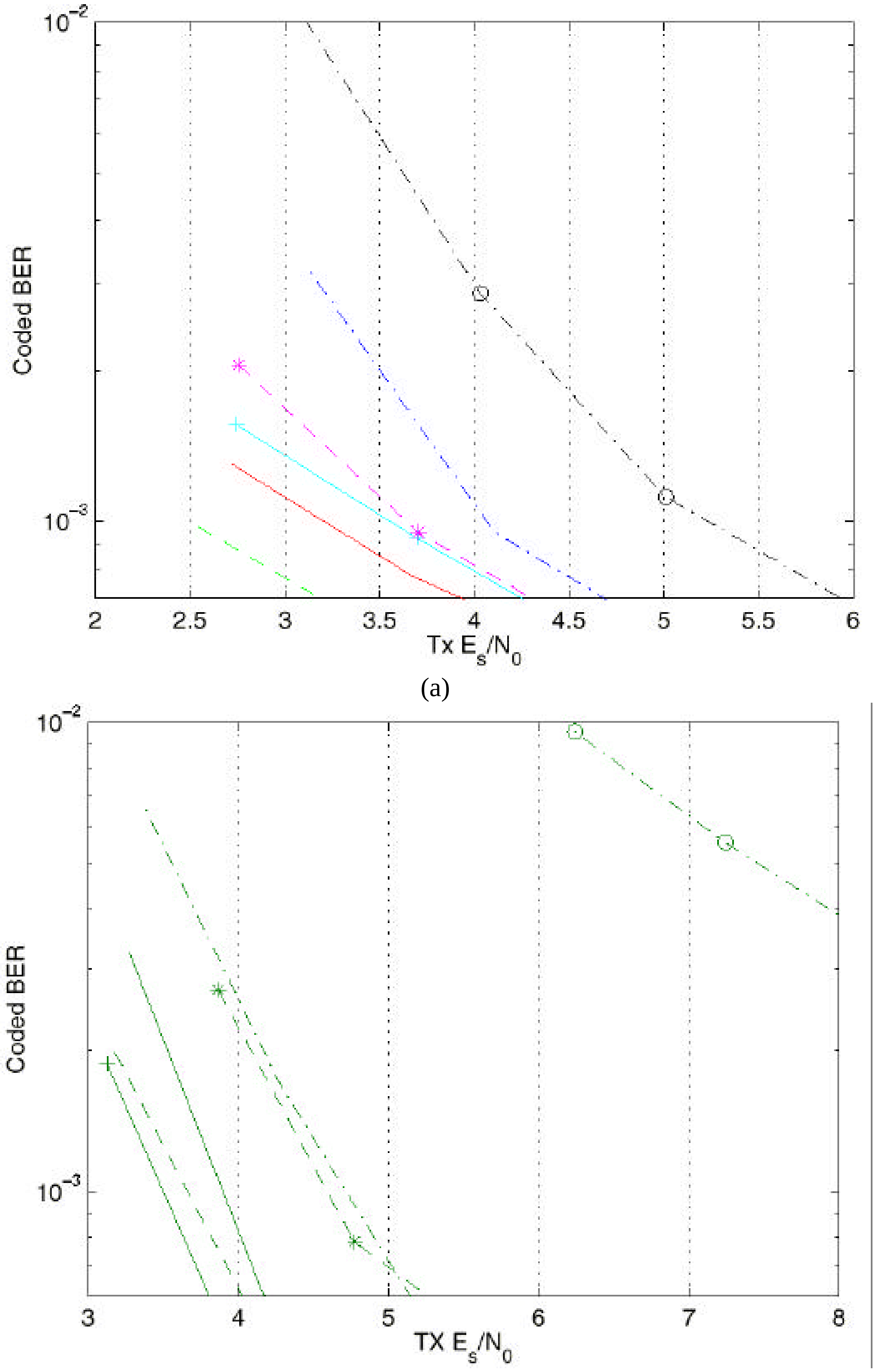
REFERENCES

[1] Ad Hoc #6. Ad Hoc #6 report to RAN WG1 meeting #5. TSG-R WG1 document, TSGR1#5(99)563, 1-4th, June, 1999, Cheju, Korea, 6 pp.

ANNEX 1: SIMULATION RESULTS

Simulation results for existing modes, Tx AA1, Tx AA2, Tx AA3, Tx AA4 and Tx AA5 and refined feedback modes RTx AA 2 and RTx AA3 are depicted in Figures 1-6. Terminals speeds 3, 10 and 40 (42.3) km/h in single tap Rayleigh, Pedestrian A and Vehicular A channels have been used.

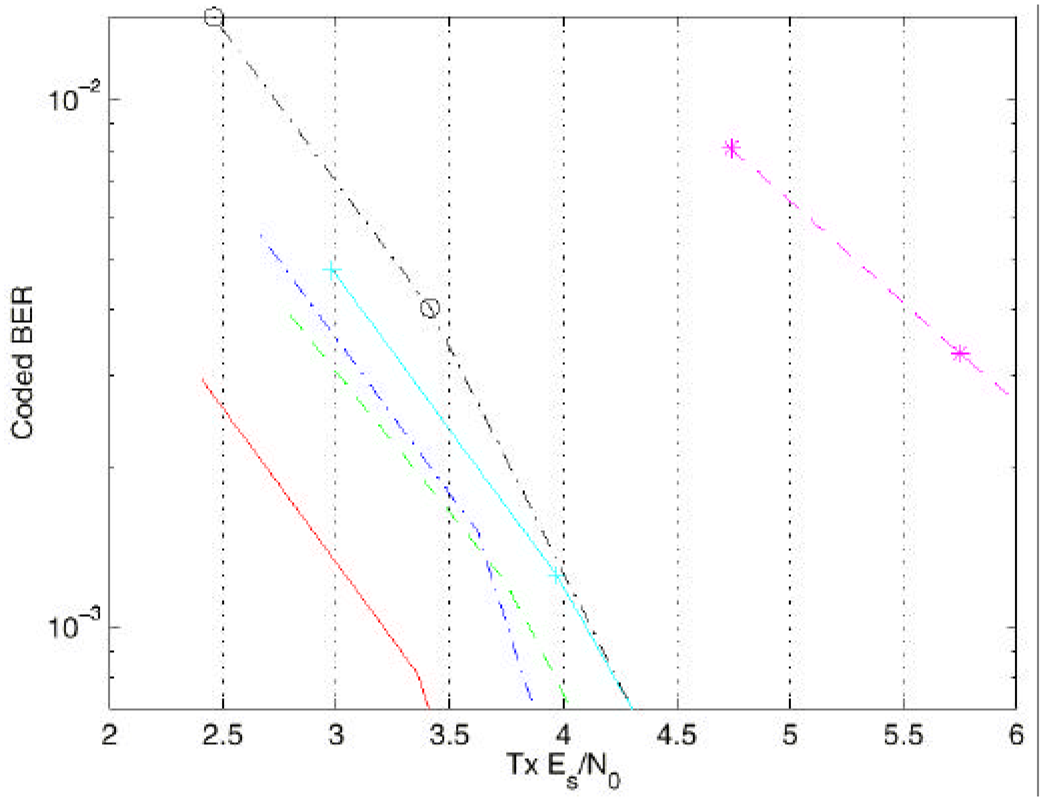
Note that some figures include other possible configurations of refined feedback modes yielding in some cases even slightly better performance than the proposed refined feedback modes. In order to minimize the number of modes and to have simple overall concept they have not been included into the proposal.



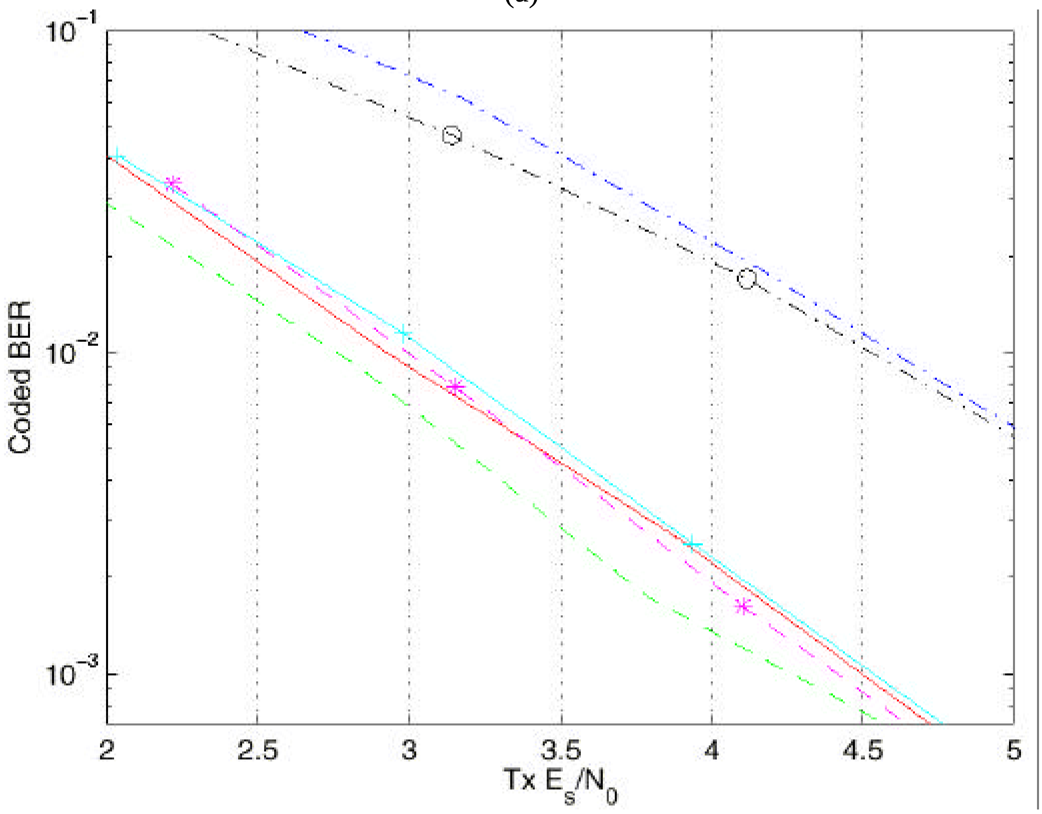
(a)

(b)

Figure 1. Coded BER for Tx AA 1 (- . -), Tx AA 2 (+), Tx AA 3(✳) and RTx AA 2 (--) as function of Tx E_s/N_o. Results for single tap Rayleigh fading channel at speeds 3 and 10 km/h are depicted in a) and b), respectively.

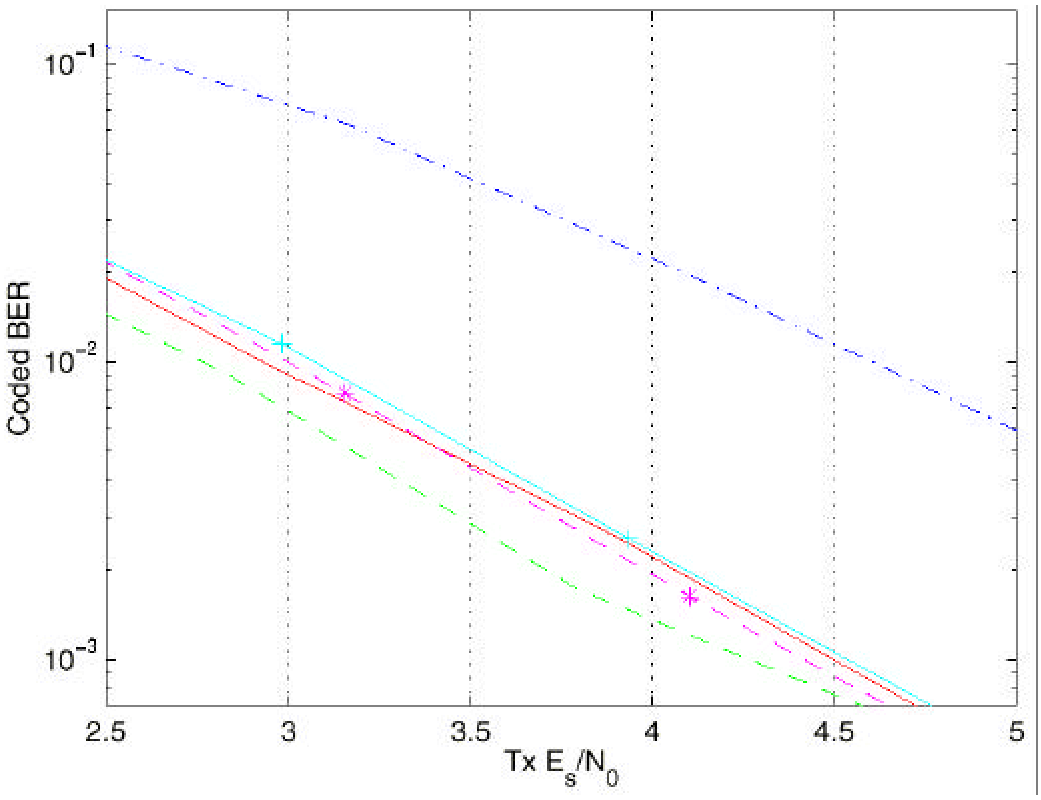


(a)



(b)

Figure 2. Coded BER for Tx AA 1 (- . -), Tx AA 2 (+), Tx AA 3(✳) and RTx AA 2 (--) as function of Tx E_s/N_o. Results for single tap Rayleigh fading channel at speed 40 km/h and Pedestrian A at 10 km/h are depicted in a) and b), respectively.



(a)

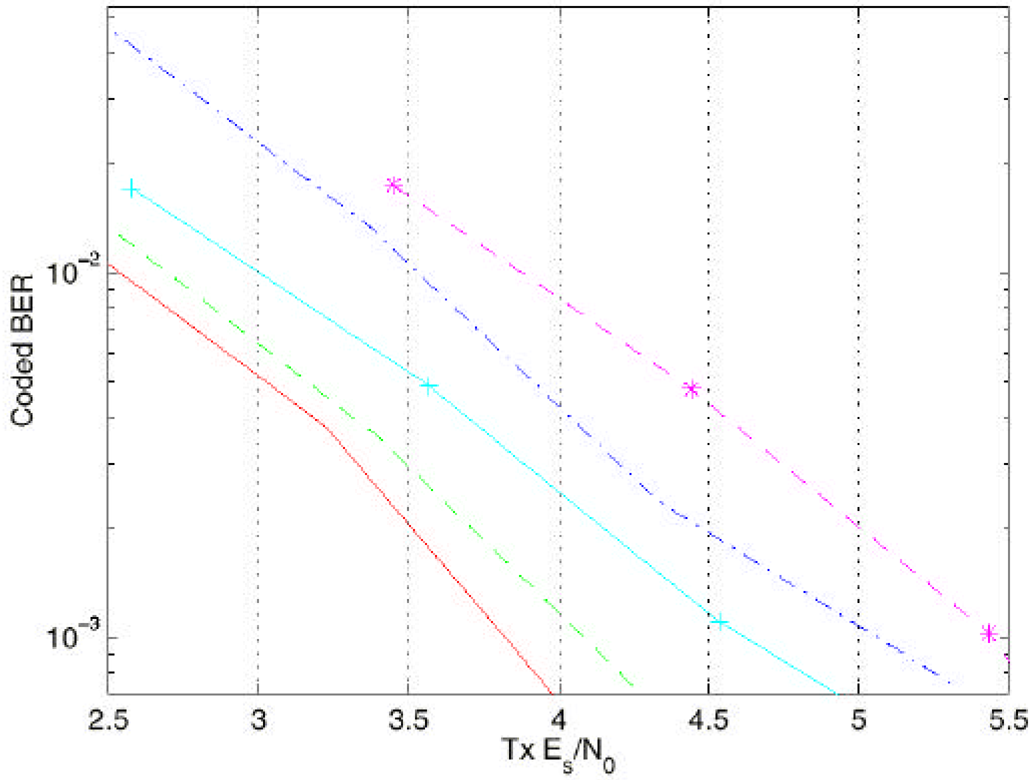
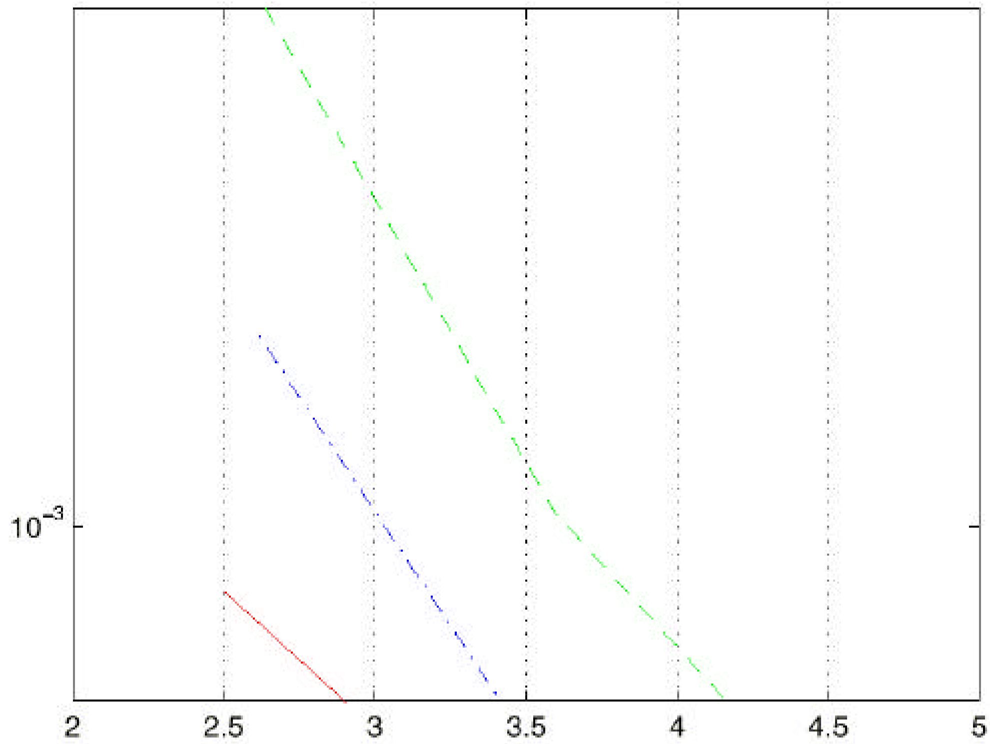
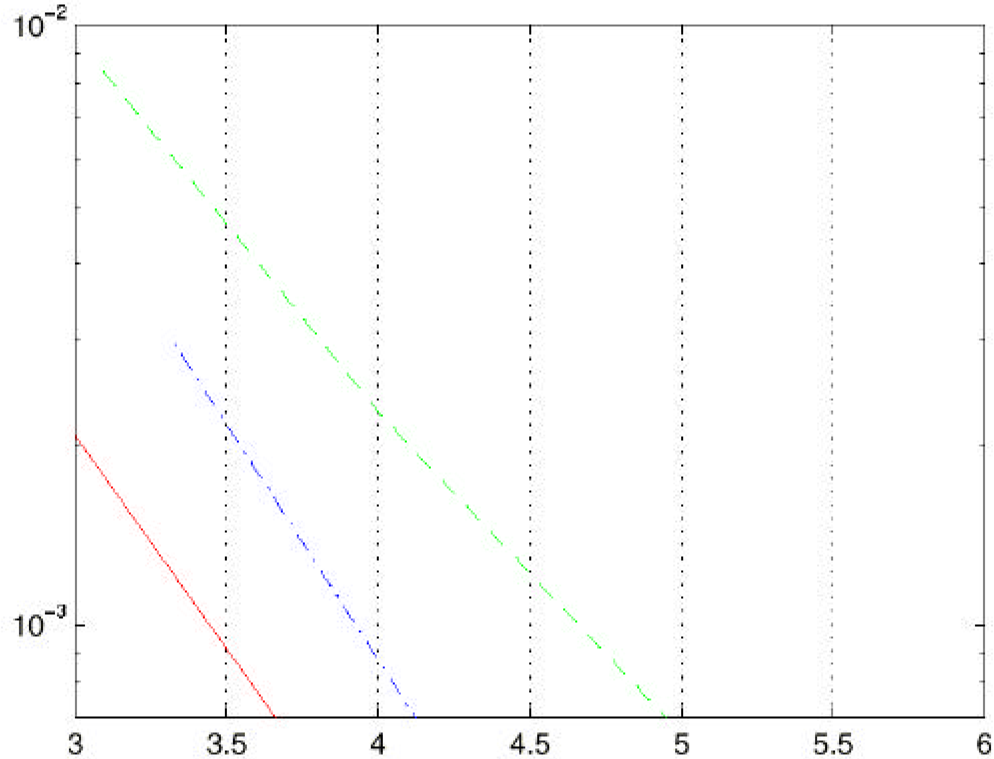


Figure 3. Coded BER for Tx AA 1 (- . -), Tx AA 2 (+), Tx AA 3(∗) and RTx AA 2 (--) as function of Tx E_s/N_o. Results for Vehicular A channel at speeds 10 and 42.3 km/h are depicted in a) and b), respectively.

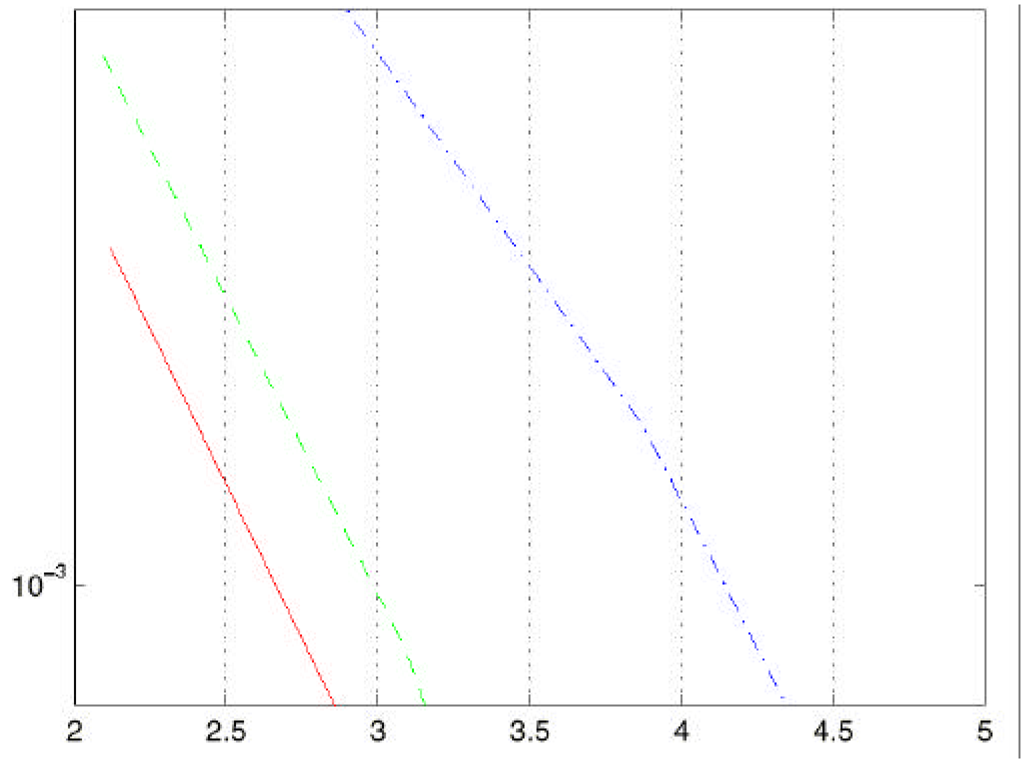


(a)

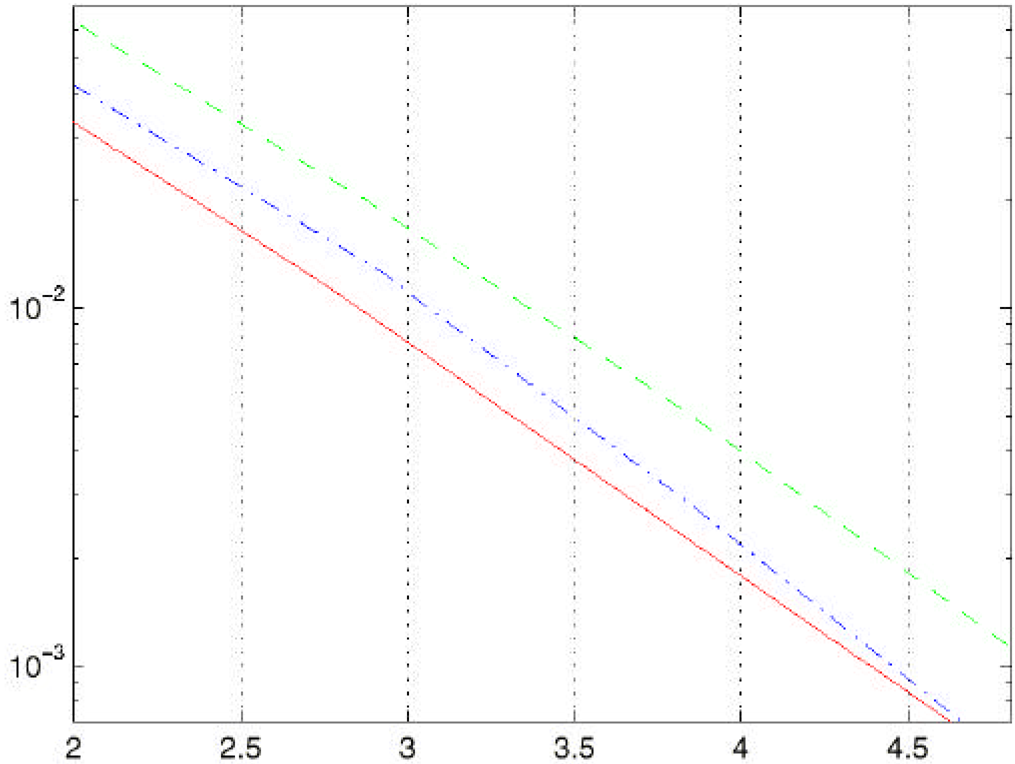


(b)

Figure 4. Coded BER for RTx AA 3 (¾), Tx AA 4 (--) and Tx AA 5(-.-) as function of Tx E_s/N_o. Results for single tap Rayleigh channel at speeds 3 and 10 km/h are depicted in a) and b), respectively.

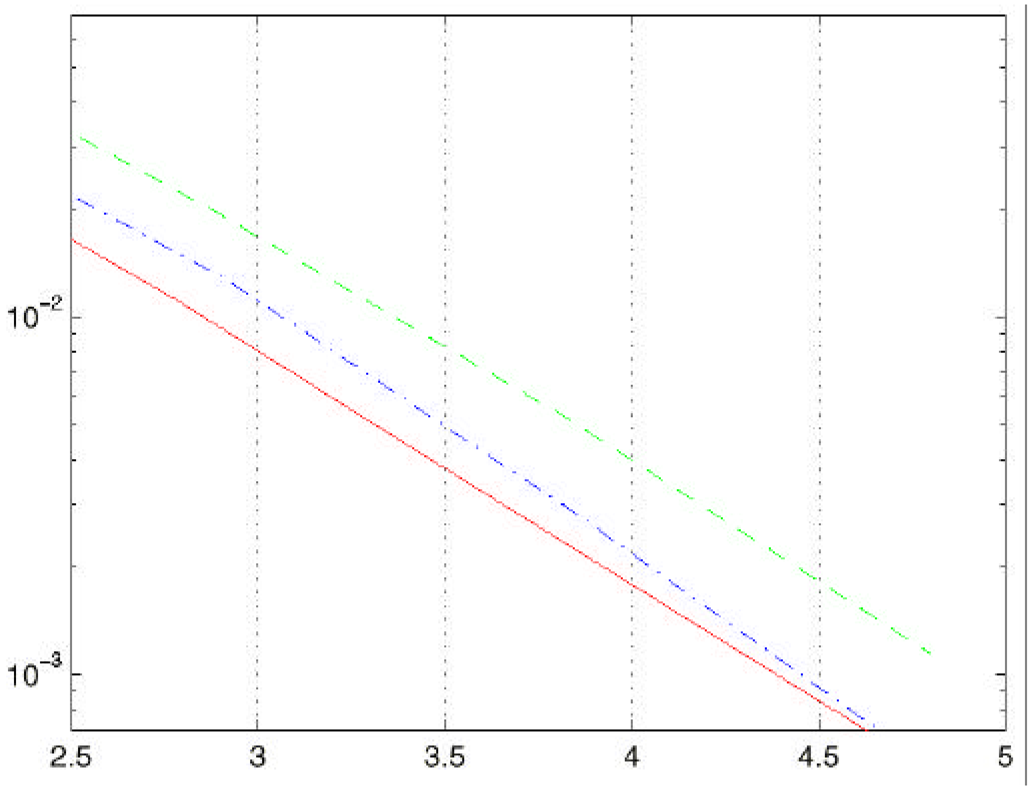


(a)



(b)

Figure 5. Coded BER for RTx AA 3 (¾), Tx AA 4 (--) and Tx AA 5(-.-) as function of Tx E_s/N_o. Results for single tap Rayleigh channel at speed 40 km/h and Pedestrian A channel at 10 km/h are depicted in a) and b), respectively.



(a)

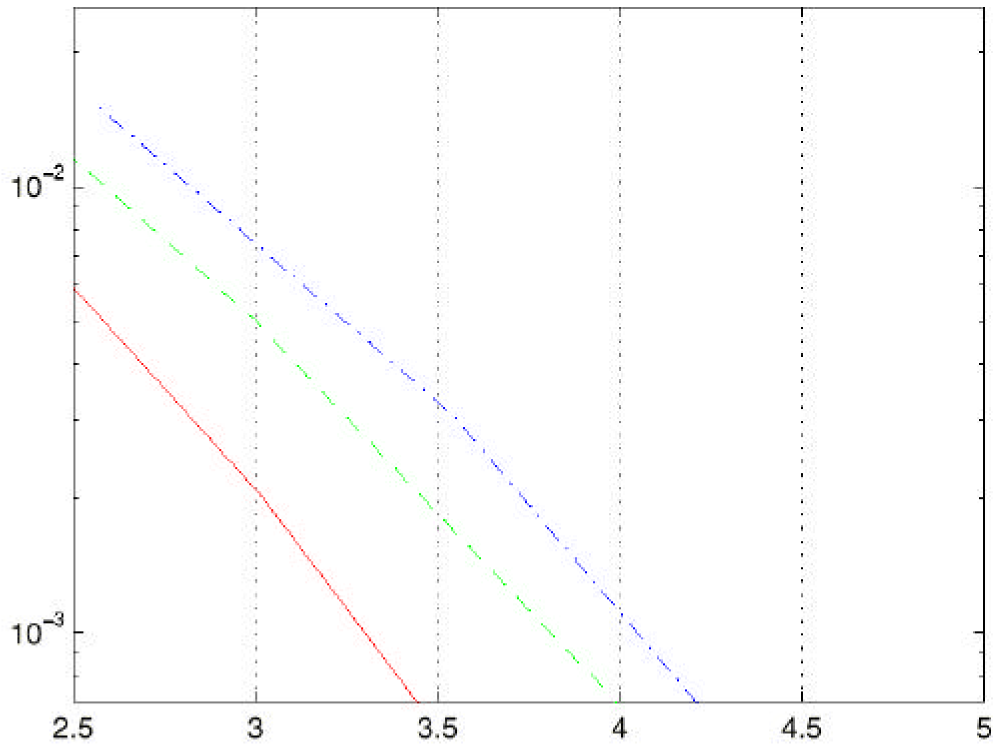


Figure 6. Coded BER for RTx AA 3 (¾), Tx AA 4 (--) and Tx AA 5(-.-) as function of Tx E_s/N_o. Results for Vehicular A channel at speeds 10 km/h and 42.3 km/h are depicted in a) and b), respectively.