TSG-RAN Working Group1 meeting #3
Stockholm 22-26, March 1999

TSGR1#3(99)140

Agenda Item:

Source: InterDigital Comm. Corp.

Title: Comparison of Detection Methods for RACH Preamble Signatures

Document for:

Summary:
The objective of this contribution is to compare the performance of several methods for RACH Preamble Detection in the presence of Doppler, using the ITU channel model.

Introduction:
In Tdoc R1-99138 it was shown that the use of differentially encoded RACH preamble signatures provide a performance advantage over the current FDD baseline for cases with high Doppler. Motorola has suggested that the differentially encoded approach be compared to a modified coherent approach using a segmented correlation of 4 segments of 4 symbols each. This contribution compares the performance of differential and segmented detection, as well as the original coherent detection approach. Previous comparisons were performed as a function of vehicle speed, assuming that the UE synchronizes its local frequency to the Base Station and transmits at that frequency. For this study, the comparisons were performed as a function of Doppler frequency, which can be a combination of vehicle speed and carrier frequency offset between the UE and the Base Station. As a reference, the following table provides an indcation of the relationship between vehicle speed on Doppler, assuming the UE frequency offset is zero and the Doppler shift is one-way:

$$\Delta f = (v/c)*f_c$$

Table 1- Doppler Shift and Vehicle Speed

Doppler Shift (Hz)	Speed (km/hr)
100	54
200	108
300	162
400	216
500	270
600	324
700	378
800	432
900	486
1000	540

The Model:
The simulation was performed for 20,000 trials for each specified SNR at each specified Doppler frequency. The range of Doppler frequencies was 0 to 1000 Hz, in steps of 100 Hz. The range of SNR used at each frequency was –2 to +9 dB, in steps of 1 dB. The simulation was run with zero range ambiguity, using the ITU channel model path 1.

Detection Performance:

Figure 1 shows the required SNR to obtain an error rate of 10E-3, for both differentially encoded and segmented correlation. It can be seen that for Doppler frequencies of 200 Hz and above, the differential processing offers a significant advantage over segmented correlation. Figure 2 shows the error rate for all three approaches at an SNR of 3 dB. Again, the advantages of differential processing can be seen for higher Doppler frequencies.

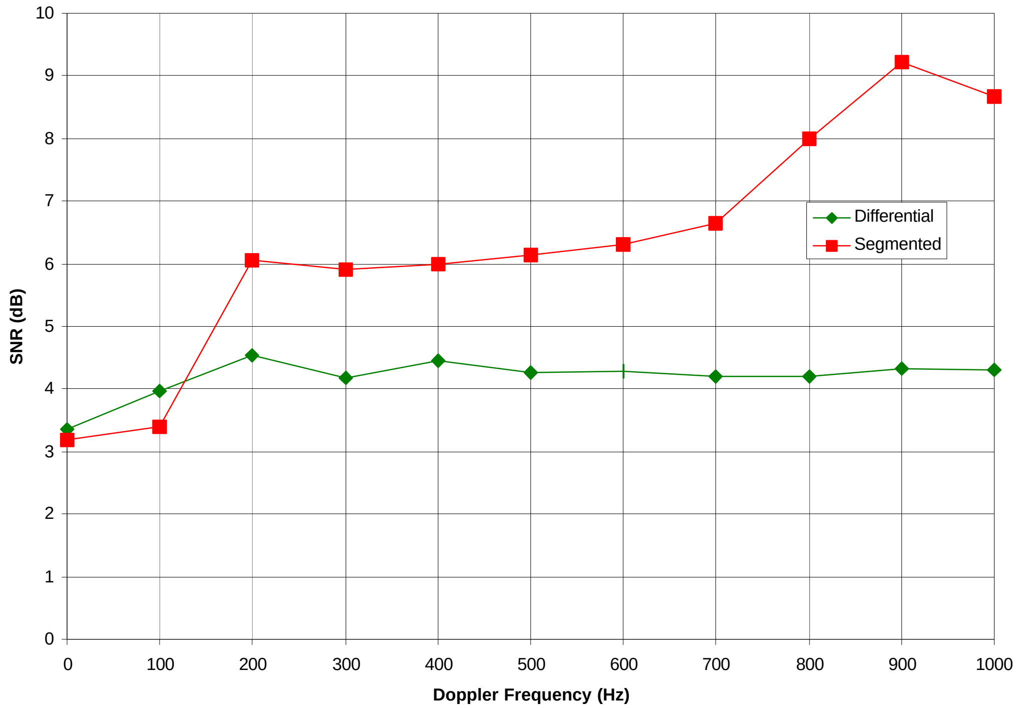


Figure 1 – Required SNR for Error Rate of 10E-3

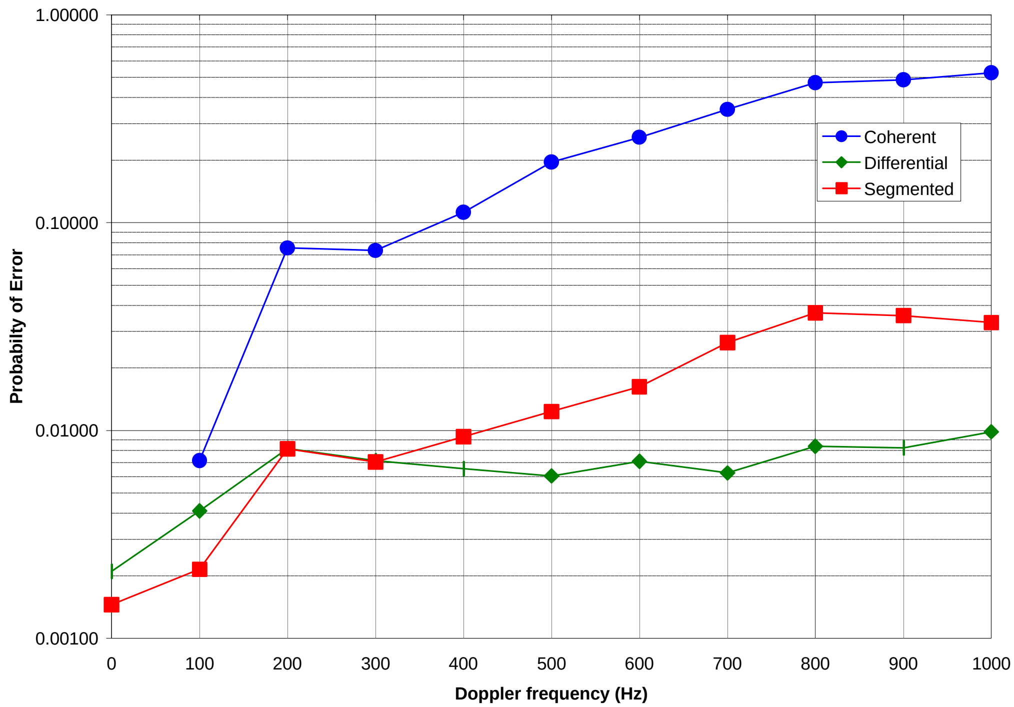


Figure 2 – Error Rate versus Doppler at 3 dB

Conclusions:

- For low Doppler frequencies, coherent detection is significantly better than either differential or segmented detection, but is unacceptable at Doppler above 100 Hz.
- Segmented correlation is slightly better at very low speeds, while differentially encoded is signifcantly better as speed increases above 200 kmh

Additional data are provided in the following Figures 3-13, illustrating Error Rate versus SNR at specific Doppler frequencies for each of the three approaches.

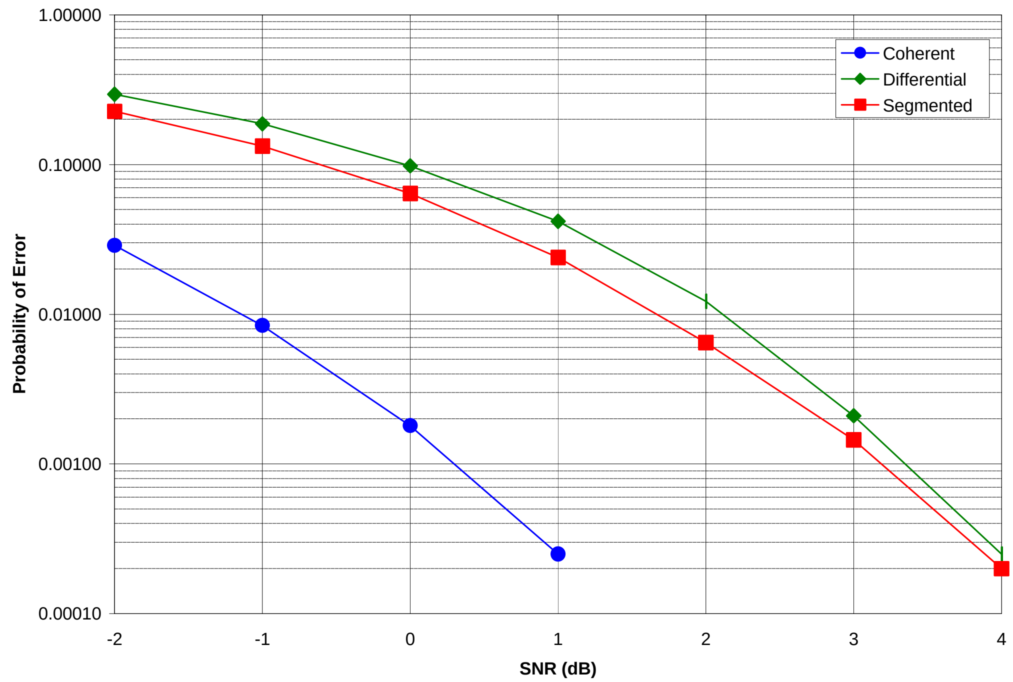
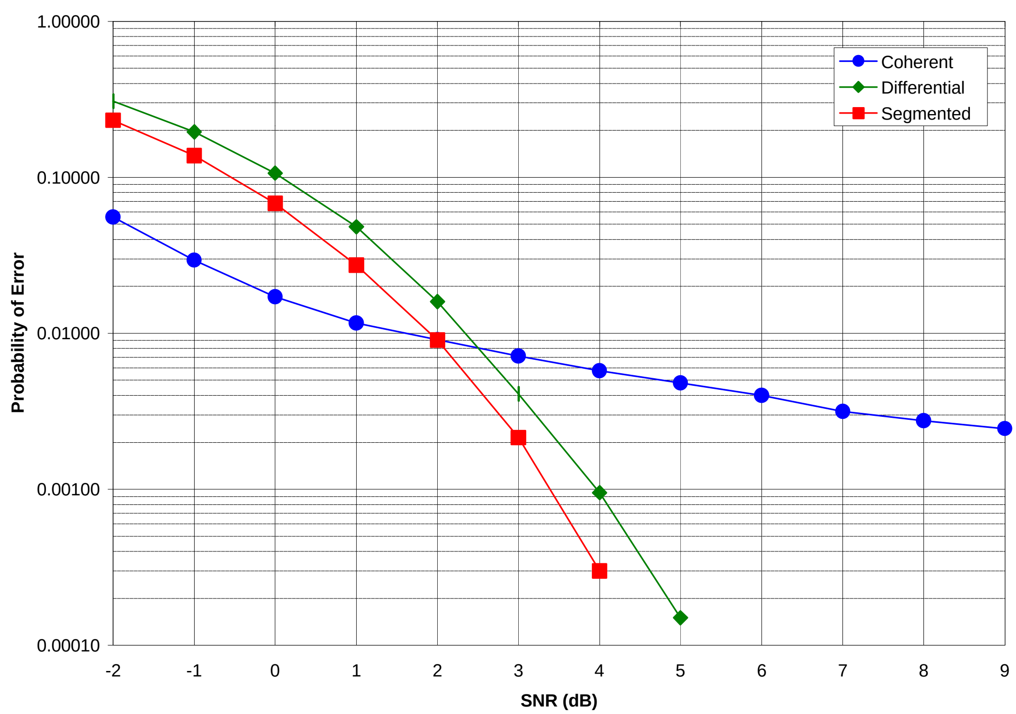


Figure 3 – Probability of Error at Doppler Frequency = 0 Hz



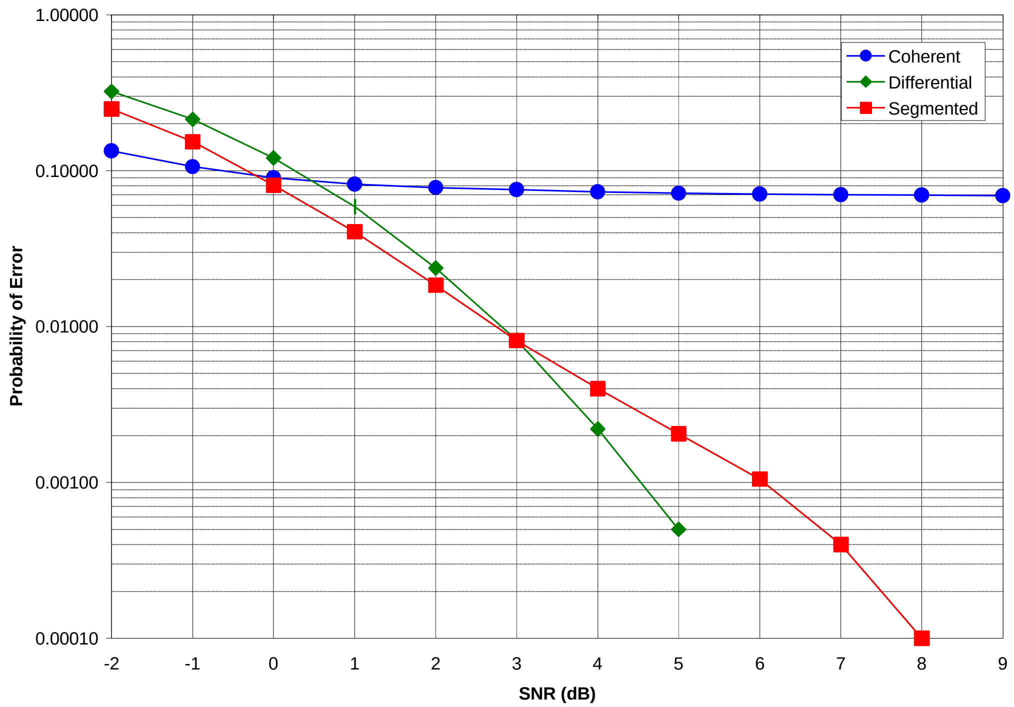


Figure 4 – Probability of Error at Doppler frequency = 100 Hz

Figure 5 – Probability of Error at Doppler Frequency = 200 Hz

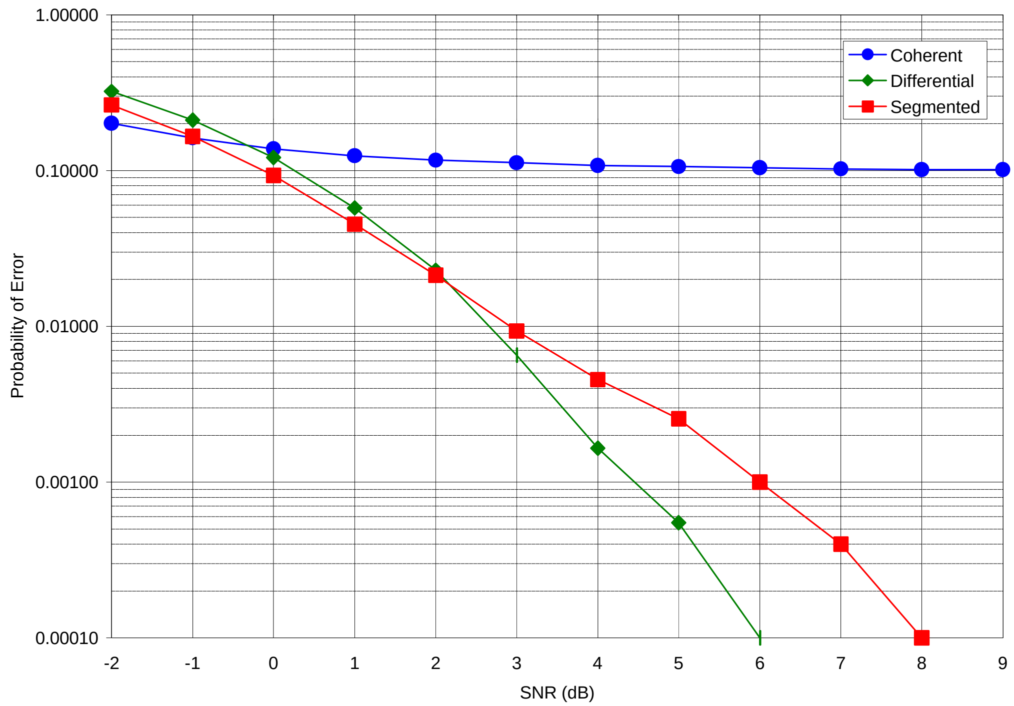
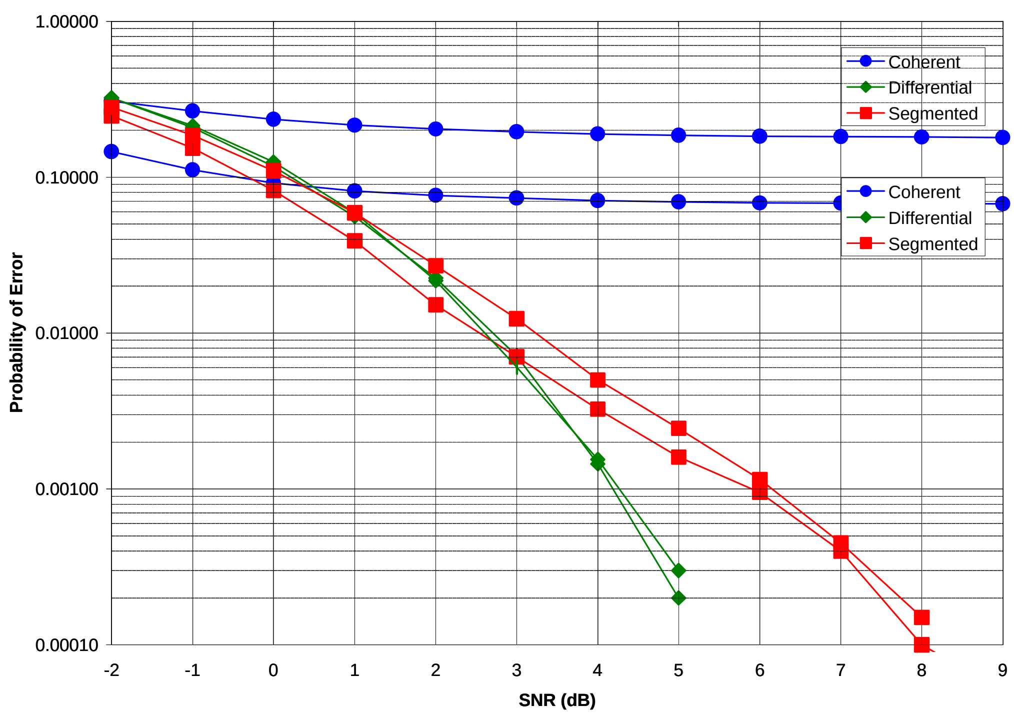


Figure 6 – Probability of Error at Doppler Frequency = 300 Hz

Figure 7 – Probability of Error at Doppler Frequency = 400 Hz



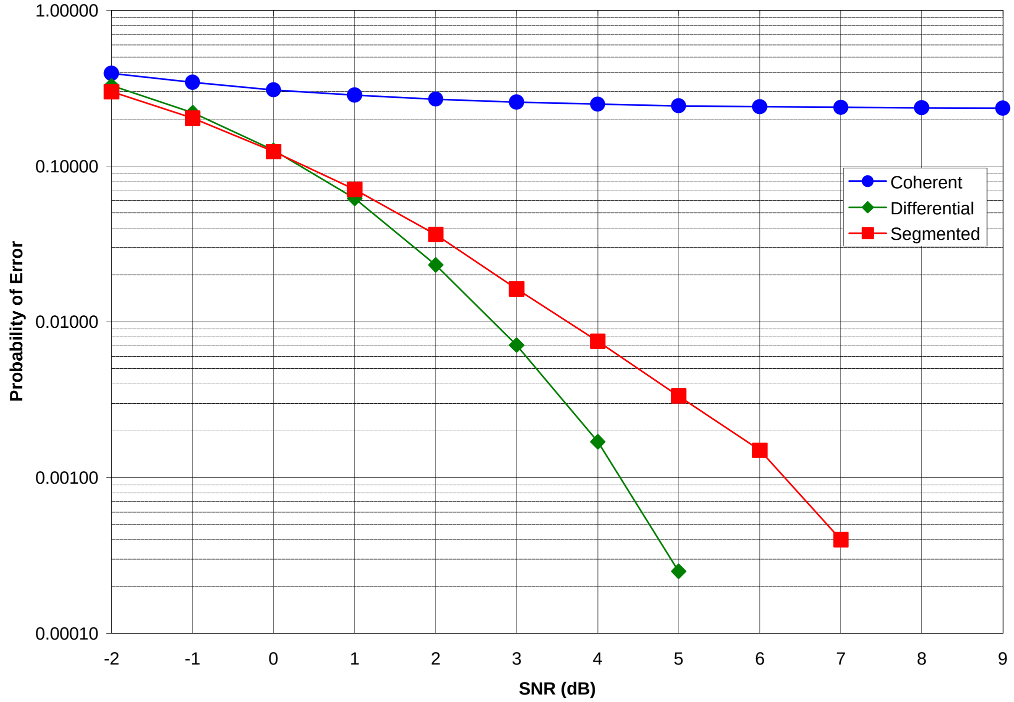


Figure 8 – Probability of Error at Doppler Frequency = 500 Hz

Figure 9 - Probability of Error at Doppler Frequency = 600 Hz

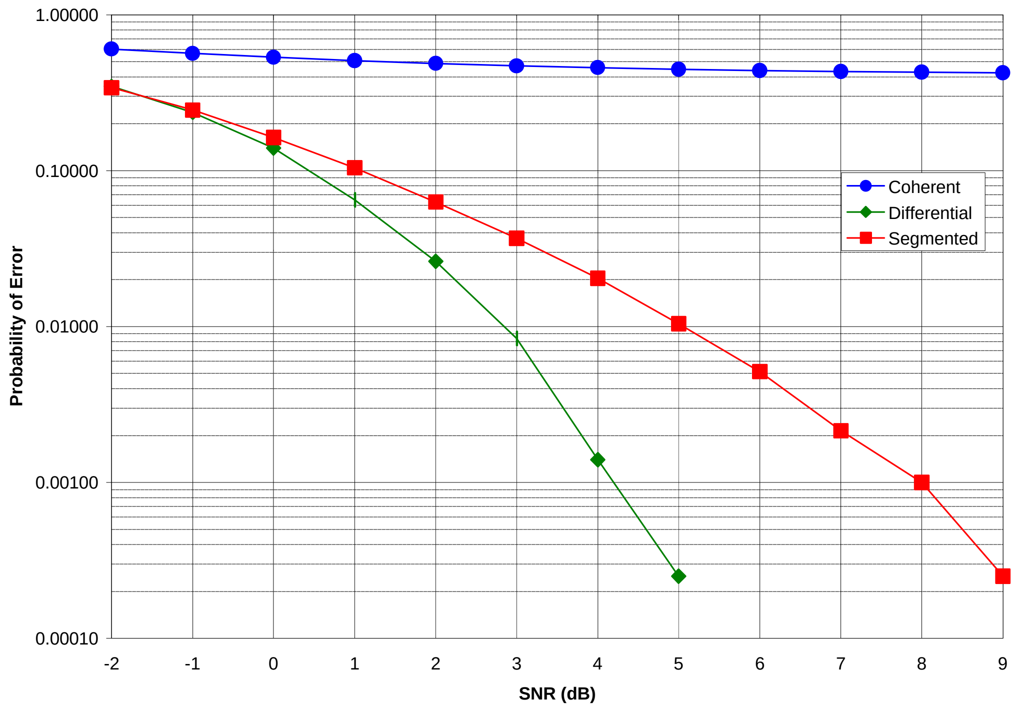


Figure 10 – Probability of Error at Doppler Frequency = 700 Hz

Figure 11 – Probability of Error at Doppler Frequency = 800 Hz

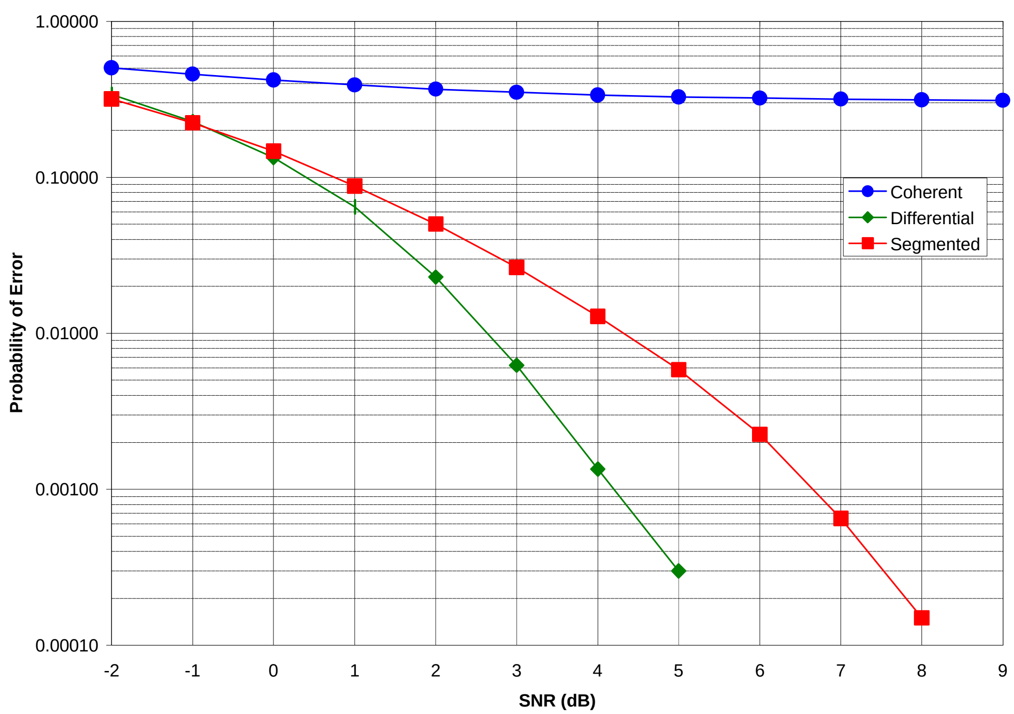
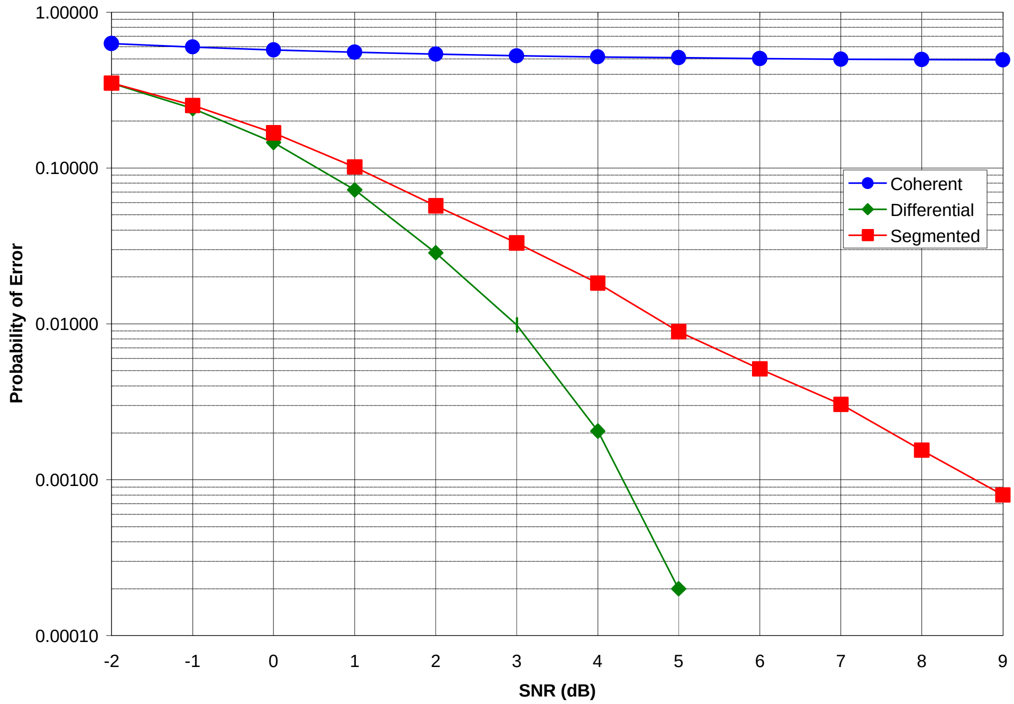


Figure 12 – Probability of Error at Doppler Frequency = 900 Hz



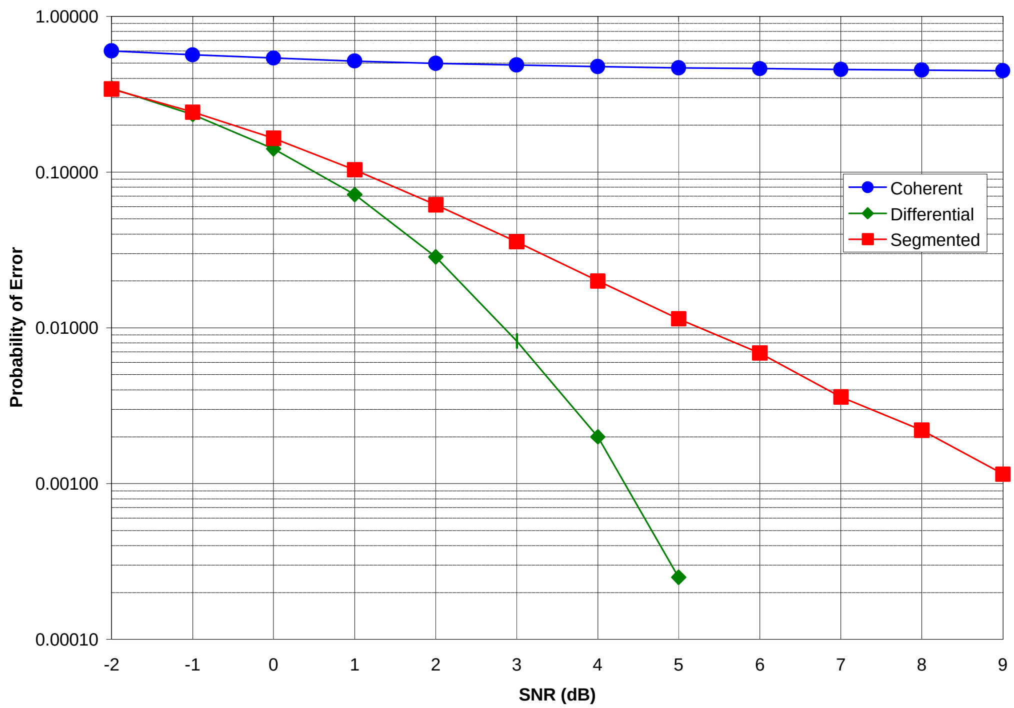


Figure 13 – Probability of Error at Doppler Frequency = 1000 Hz