

A Study on Simulating Convolutional Codes and Turbo Codes

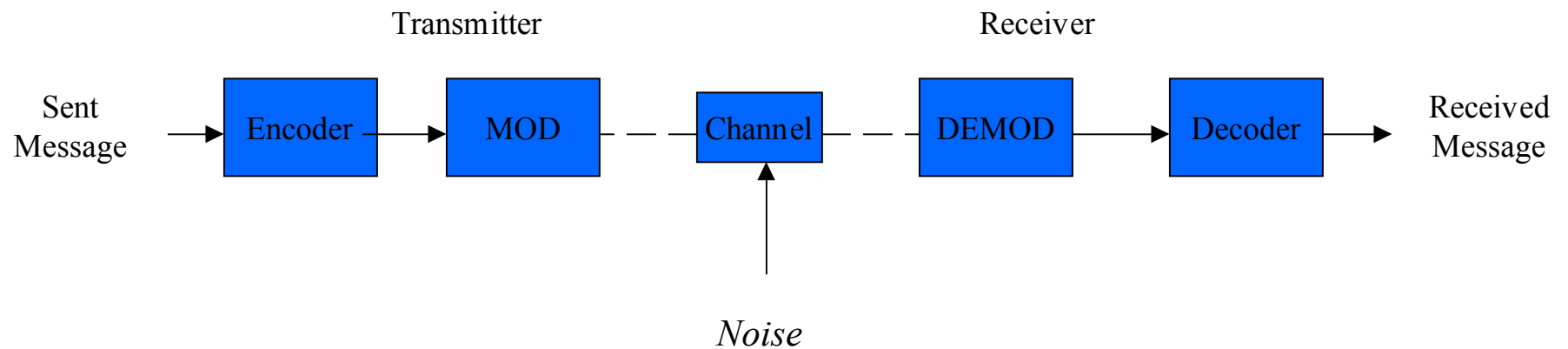
By

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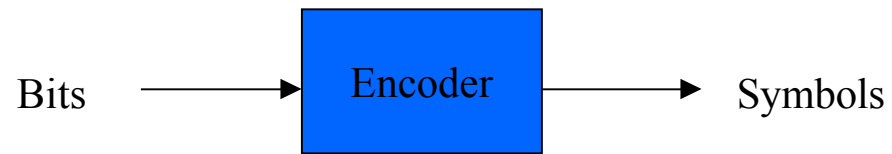
Introduction

- Digital Communication Systems



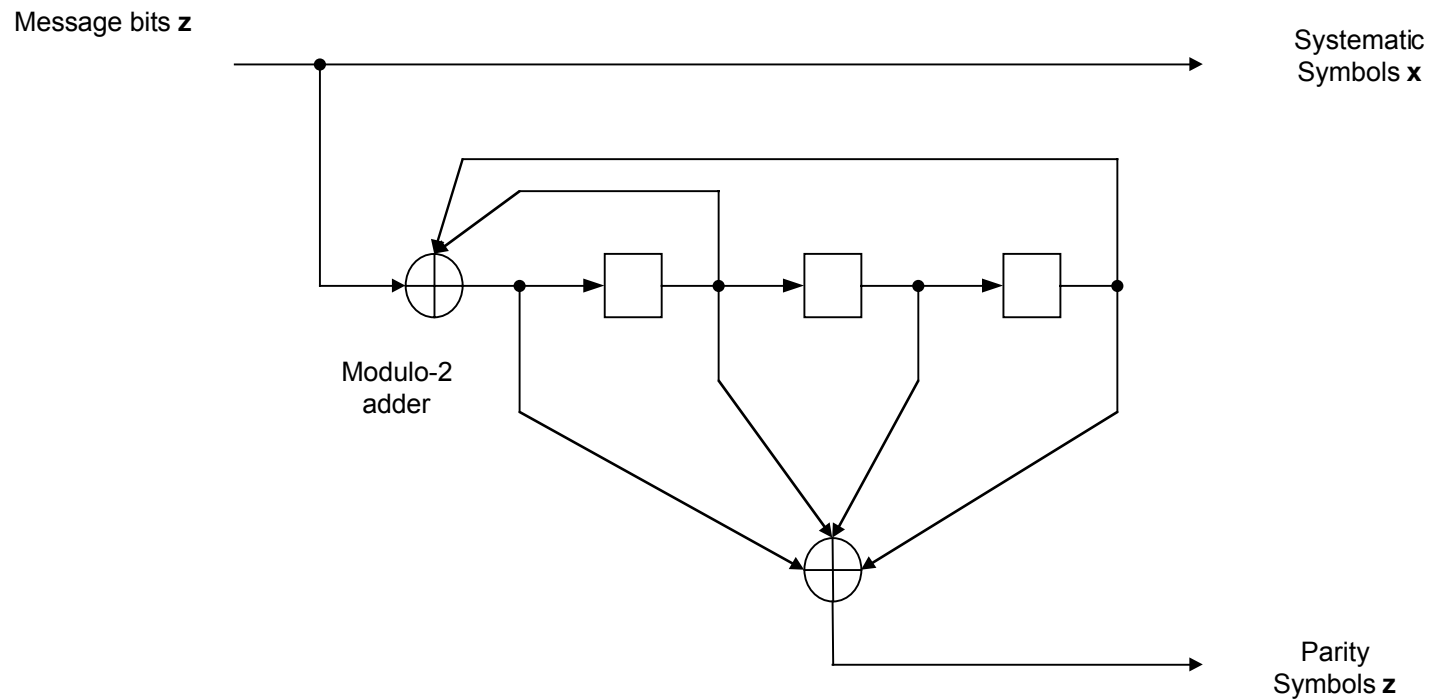
- Error Correction Coding
- Adding Redundancy to Message Bits

Encoding

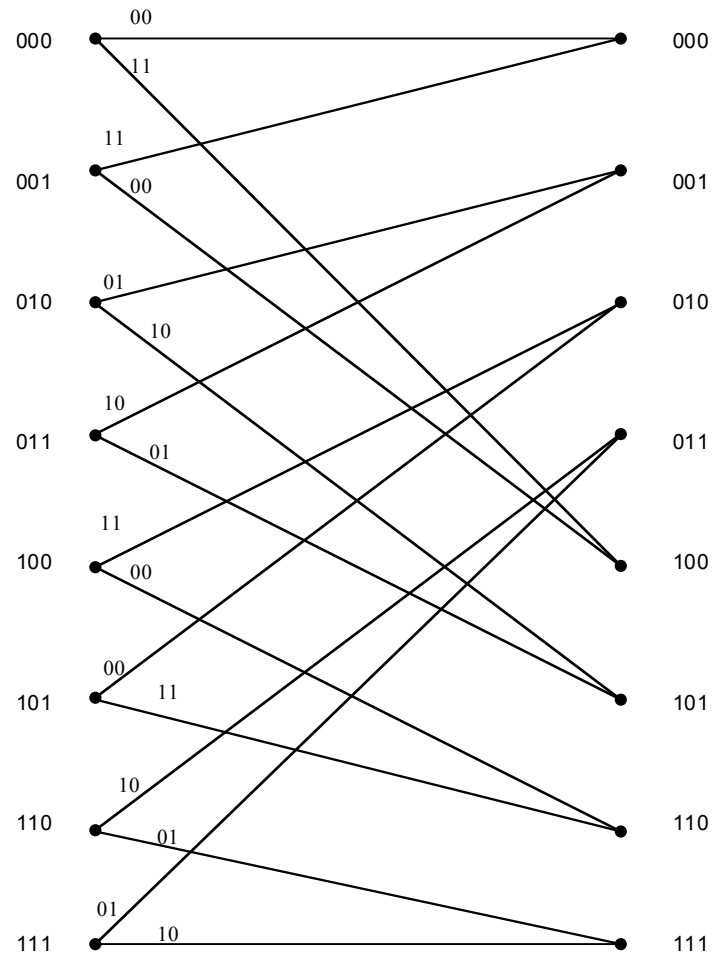


$$Rate = \frac{bits}{symbols}$$

8 State Recursive Systematic Convolutional (RSC) Encoder

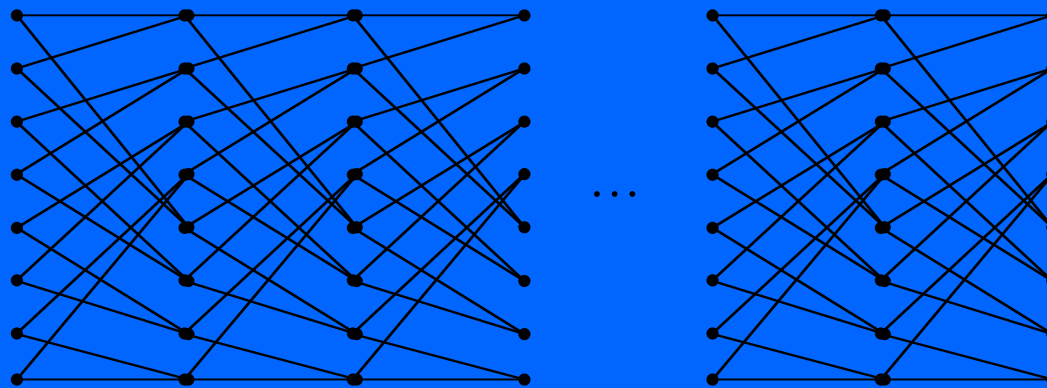


Trellis Diagram for 8 State RSC

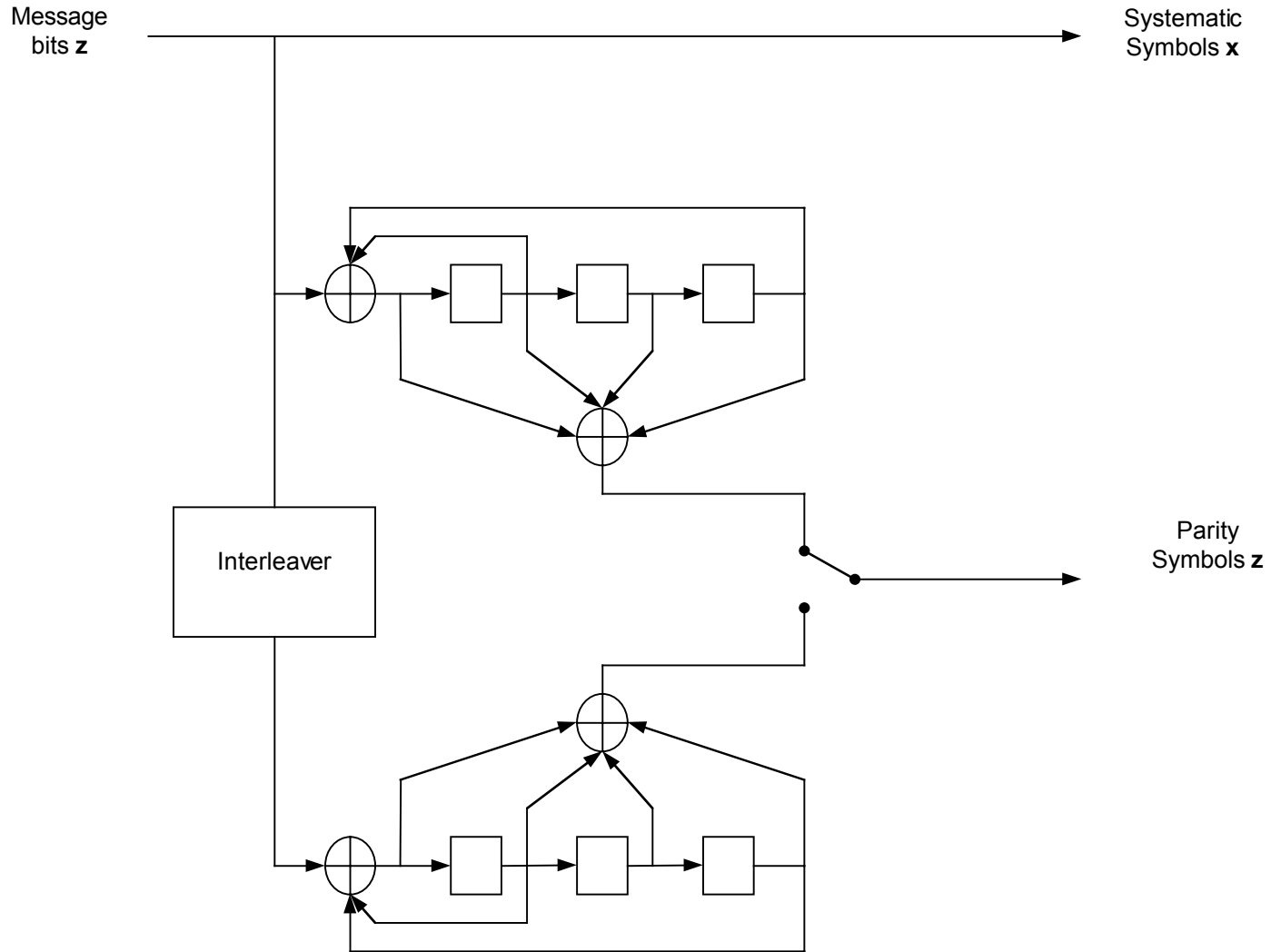


Decoding

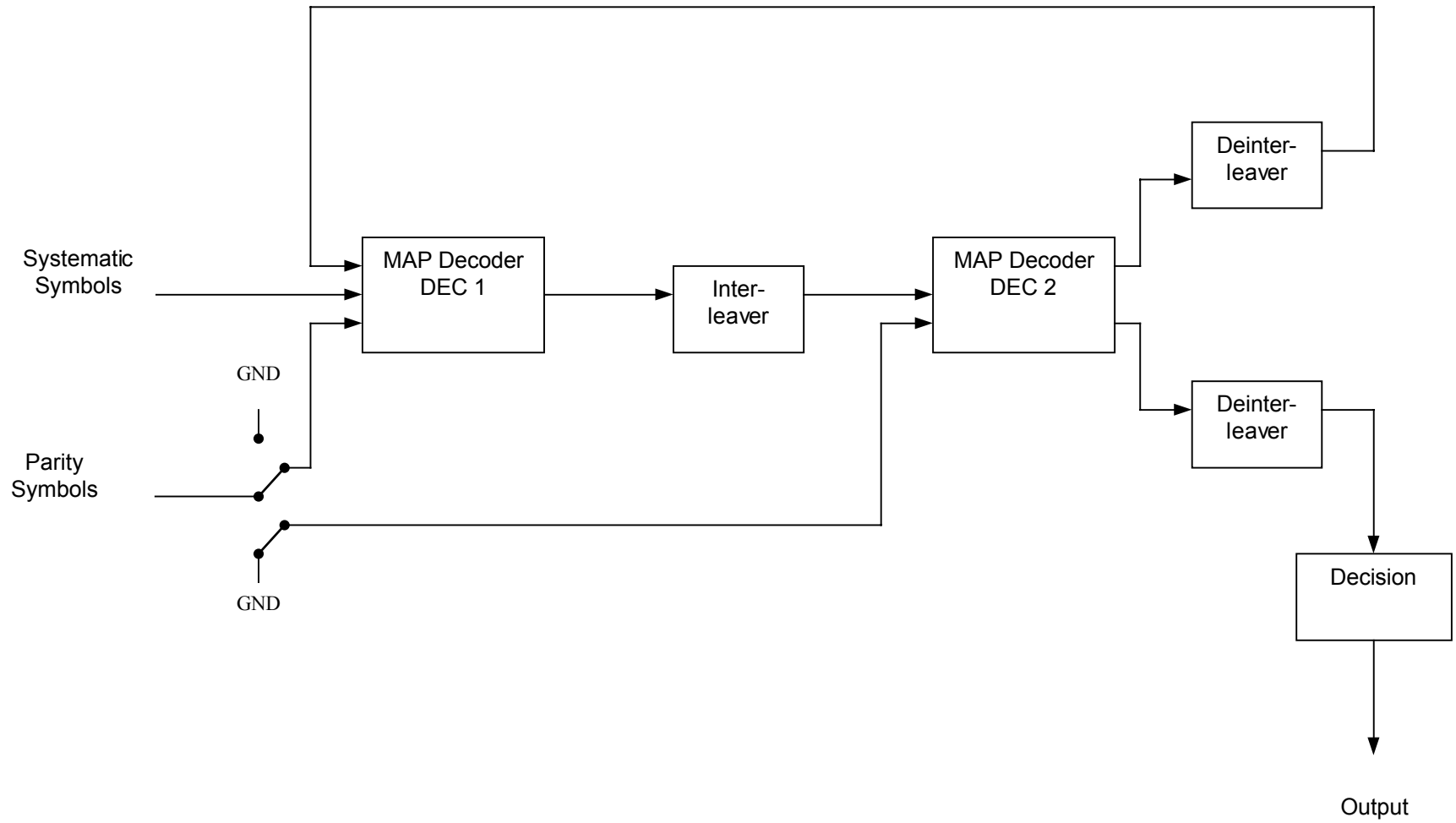
- Minimum Distance Decoding
- Viterbi Algorithm
 - Best path based on observed symbols through Trellis, left to right
- Hard Decisions – Hamming Distance
 - If noisy symbol > 0 , guess 1
 - If noisy symbol < 0 , guess 0
- Soft Decisions – use noisy symbols, Euclidean Distance
- Puncturing – using every other parity bit



Turbo-code Encoder



Turbo-code Decoder



Symbol by Symbol Maximum *A Priori* (MAP) Decoding

- Calculate γ for each transition in trellis
 - proportional to probability
- Calculate α for each node in trellis
 - left to right
 - conditional probability
- ♣ Calculate β for each node in trellis
 - right to left
 - proportional to conditional probability
- Calculate extrinsic likelihood from β, α, γ

Channel Model

- Zero-Mean Additive White Gaussian Noise (AWGN)
- Given Variance

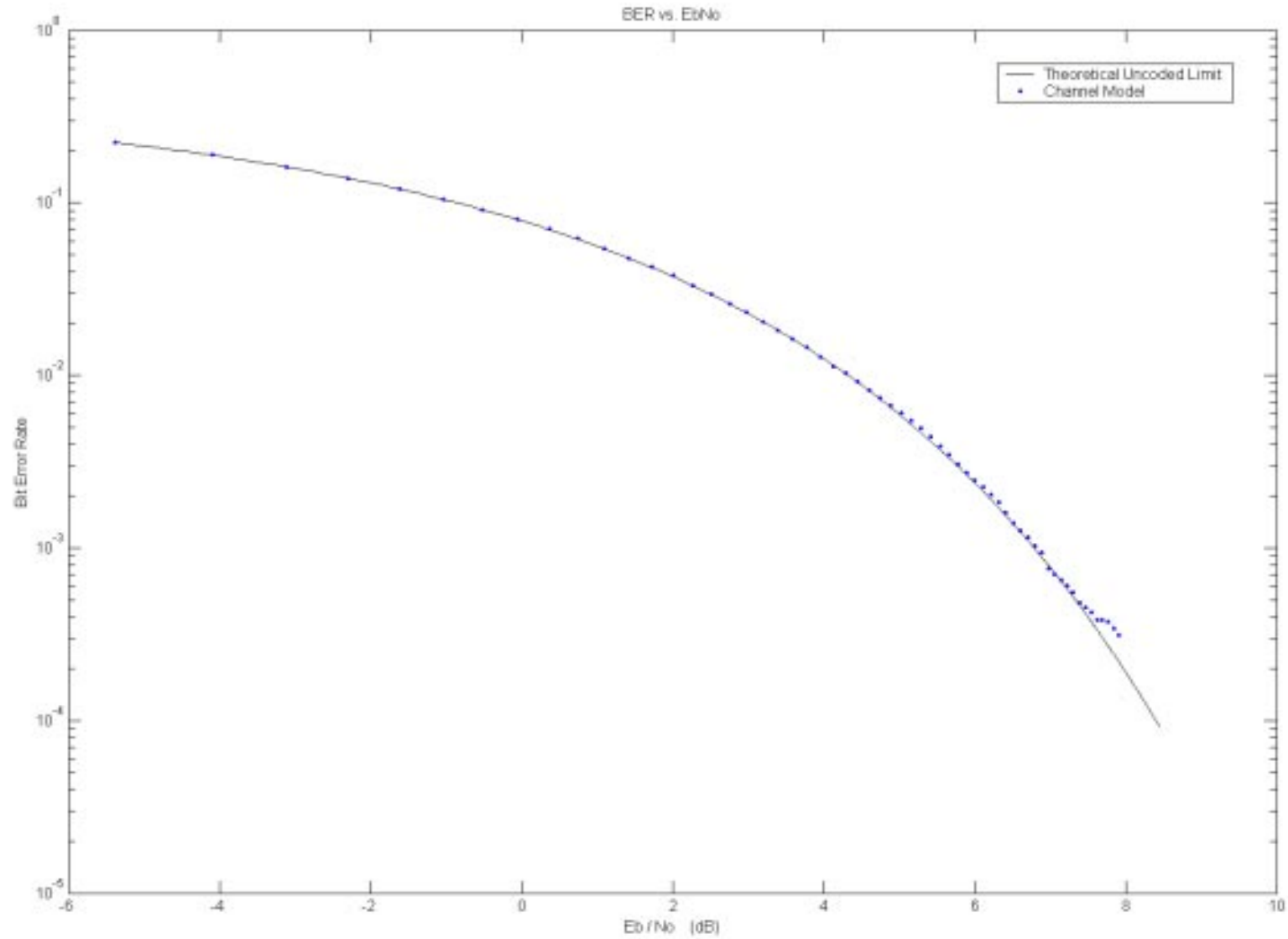
$$\sigma^2 = \frac{1}{2 \cdot \frac{E_s}{N_0}}$$

$$E_s = E_b$$

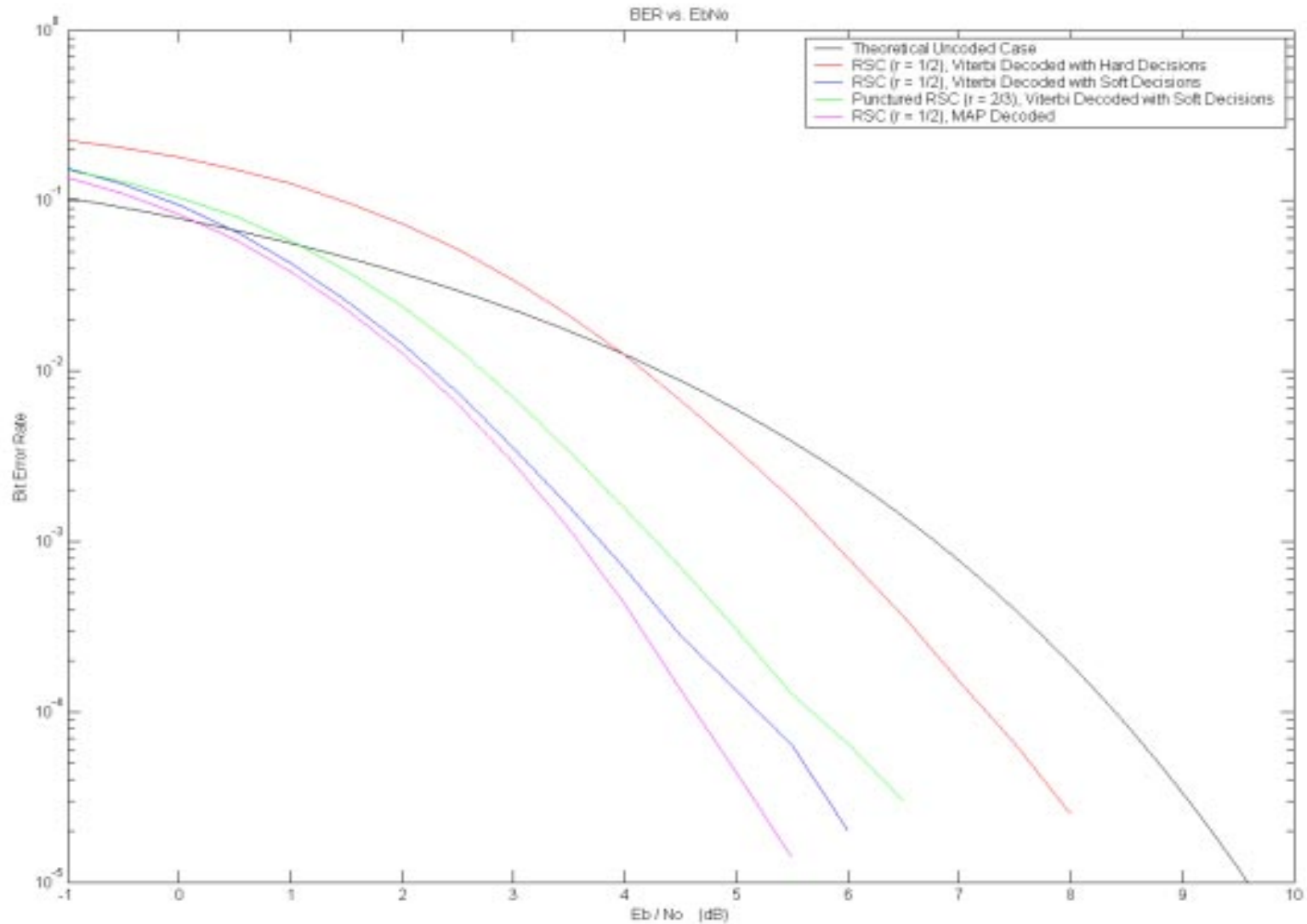
- Theoretical Performance in terms of Bit Error Rate (BER) for antipodal signaling is

$$BER = \frac{1}{2} \operatorname{erfc}\left(\sqrt{E_b / N_0}\right)$$

Channel Model Performance

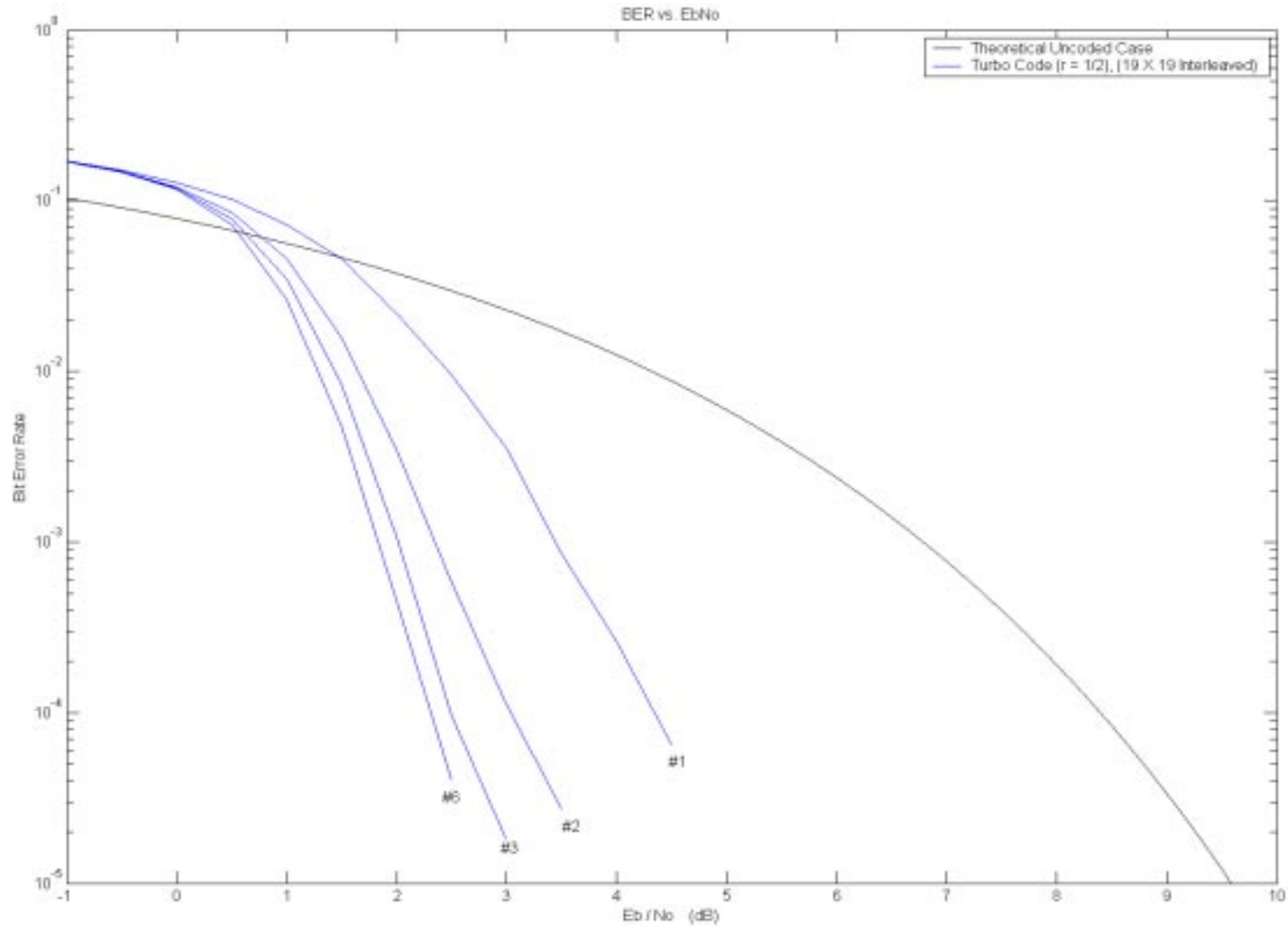


Performance of RSC Codes

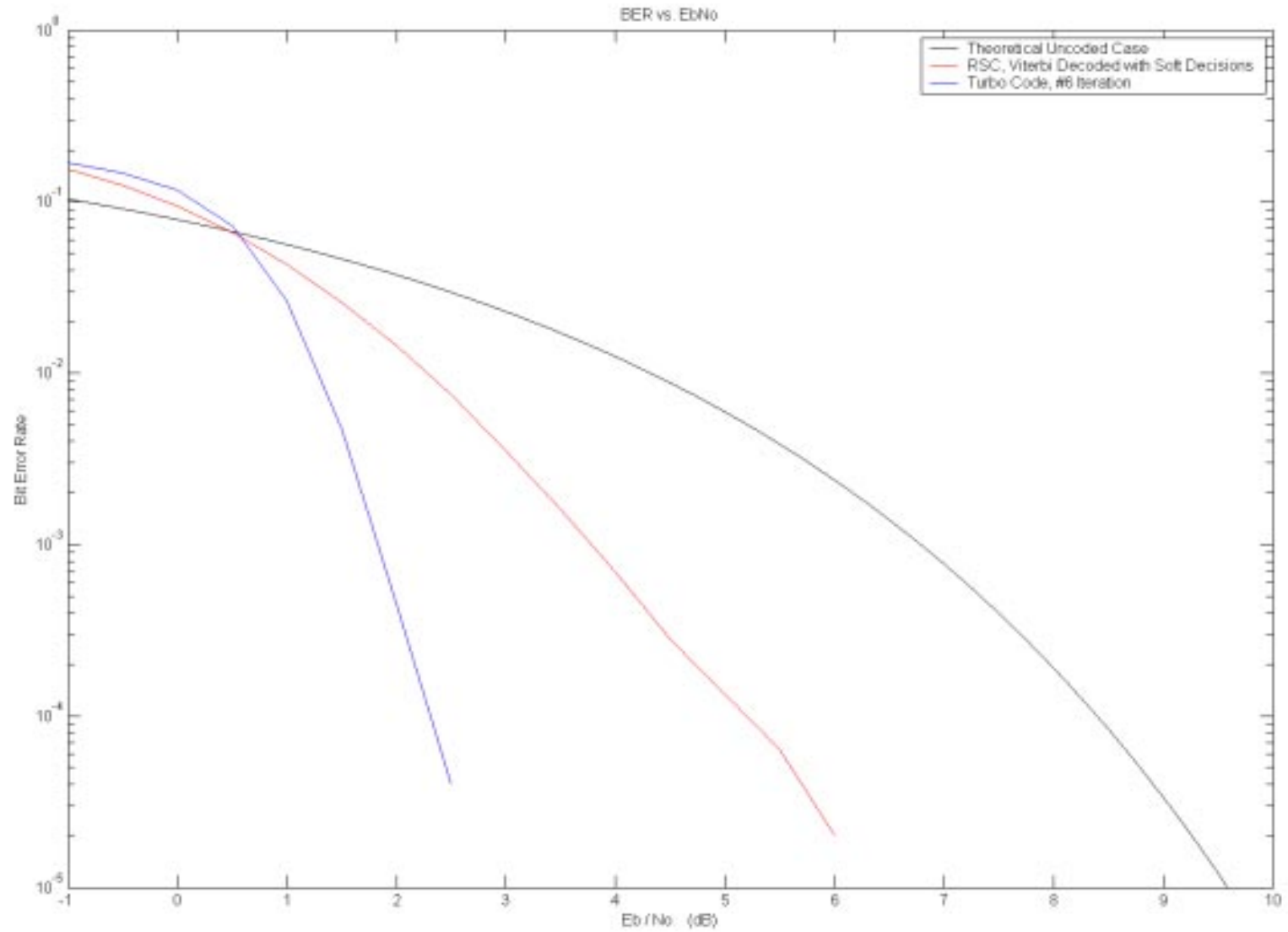


361 Bit Blocks

Performance of Turbo Code



Turbo Code vs. RSC



Questions?