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Turbo Coded Continuous Phase Modulation

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Joint work with Upmanyu Madhow, University of California
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Outline

- Motivation
- System Architecture
- Choice of Parameters
- Capacity Results
- Performance
- Conclusions

Motivation

- Design a turbo-coded continuous phase modulation system
- Compare its performance to M-PSK modulated systems

System Architecture

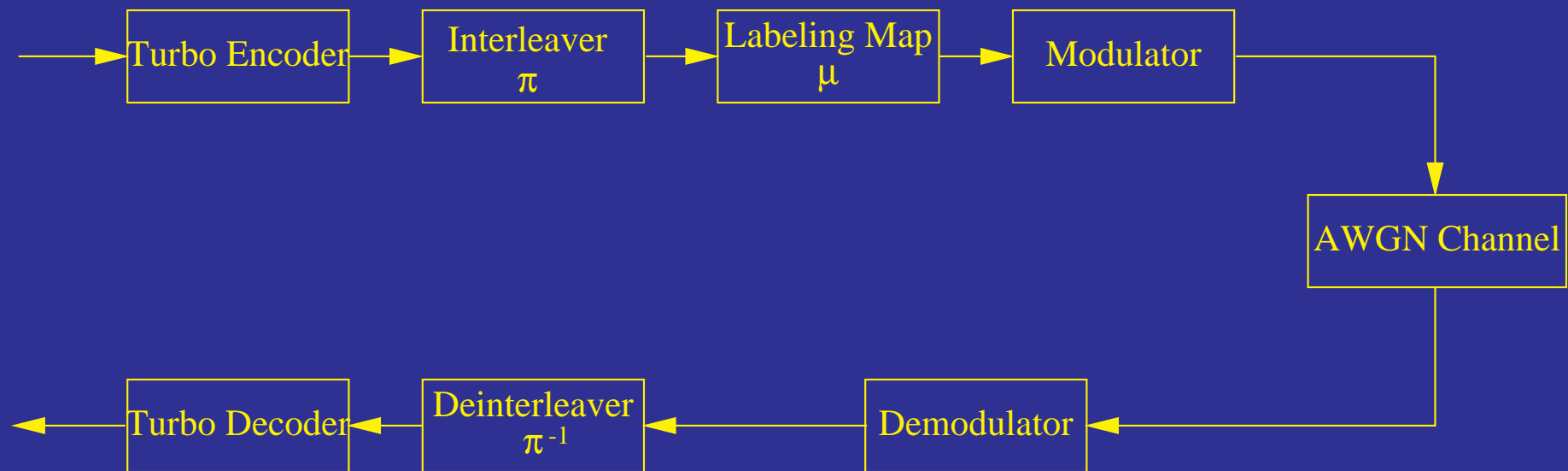
(Choice of Coded Modulation)

Turbo codes are predominantly binary, while CPM schemes are energy-efficient only for $M = 4$ and 8 .

Bit Interleaved Coded Modulation	Multilevel Coded Modulation
Simpler to implement	More intricate to implement
Theoretically suboptimal	Theoretically optimum

System Architecture

(Block Diagram)



Demodulator = BCJR algorithm on Rimoldi's time invariant trellis

Choice of Parameters

Turbo codes

Rate 1/2

Generator Polynomials= $\{D^4 + D^3 + D^2 + D + 1, D^4 + 1\}$

$N = 32768$

CPM Parameters

$M = 4, 8$

Frequency response pulse: CPFSK, 3RC, 3REC

Choosing $h = \frac{K}{P}$ is the most involved part. Recall that demodulator has PM^{L-1} states.

$$\Rightarrow h = \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, \frac{2}{3}, \frac{3}{4}, 1, \frac{5}{4}, \frac{4}{3}, \frac{3}{2}$$

Choice of Parameters

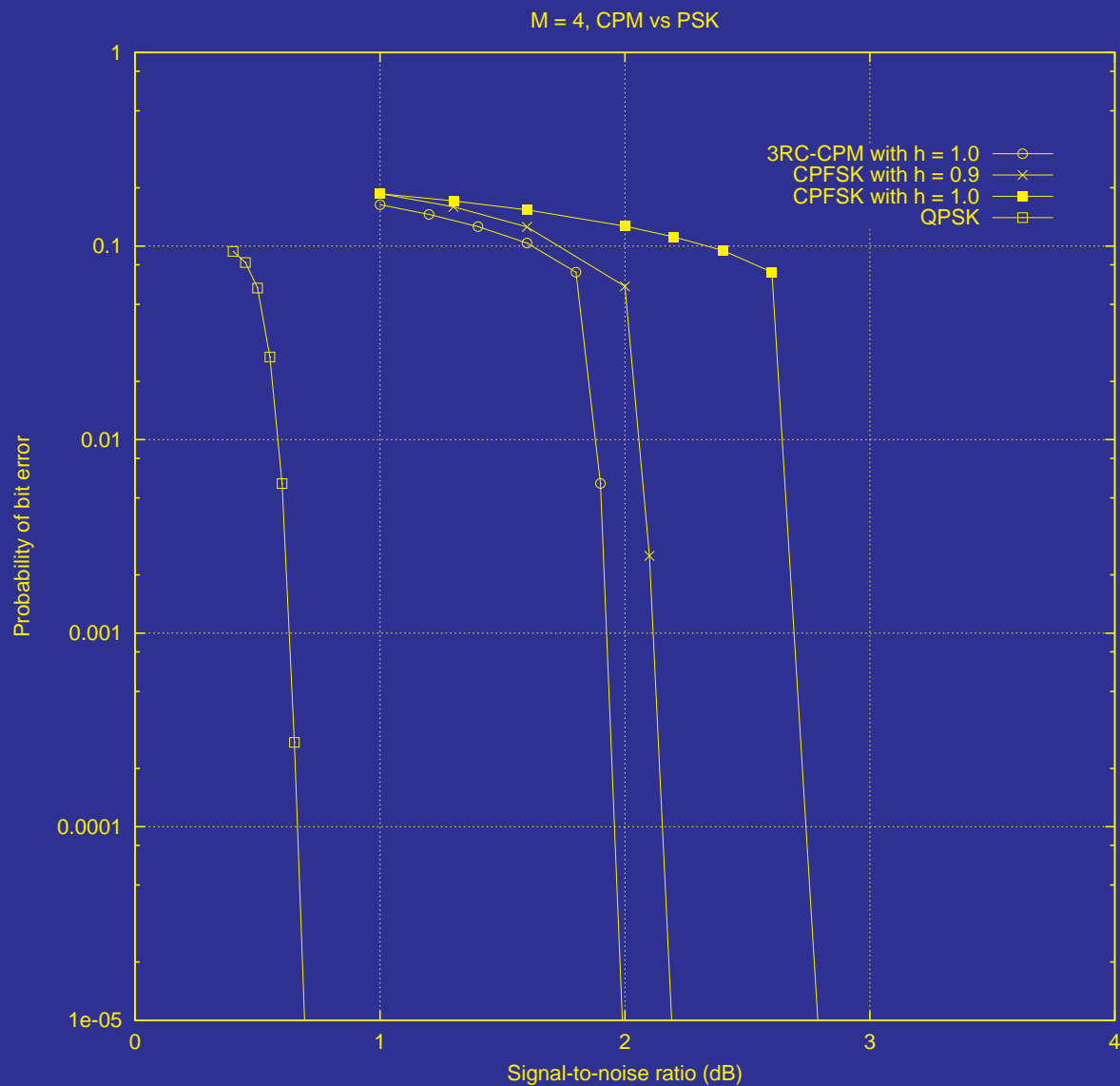
(Choice of h)

Values of h that require lowest SNR to achieve 13% uncoded bit-error-rate

M	2	4	8
$g(t)$			
CPFSK	$\frac{7}{10}$	$\frac{9}{10}$	$\frac{9}{10}$
3RC	$\frac{4}{5}$	1	1
3REC	\times	$\frac{6}{5}$	$\frac{6}{5}$

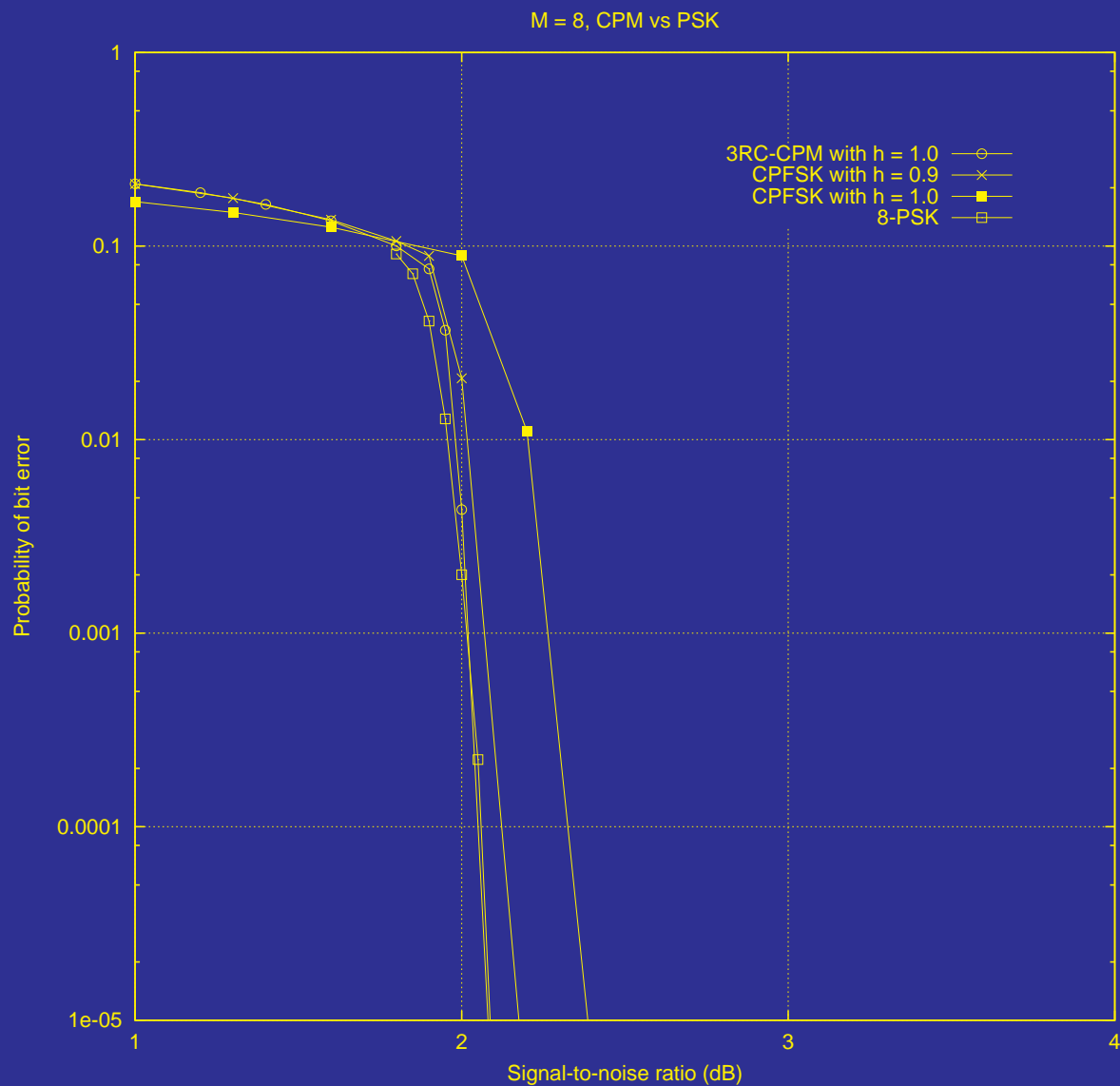
Performance of CPM Signaling

3RC Modulation, $M = 4$



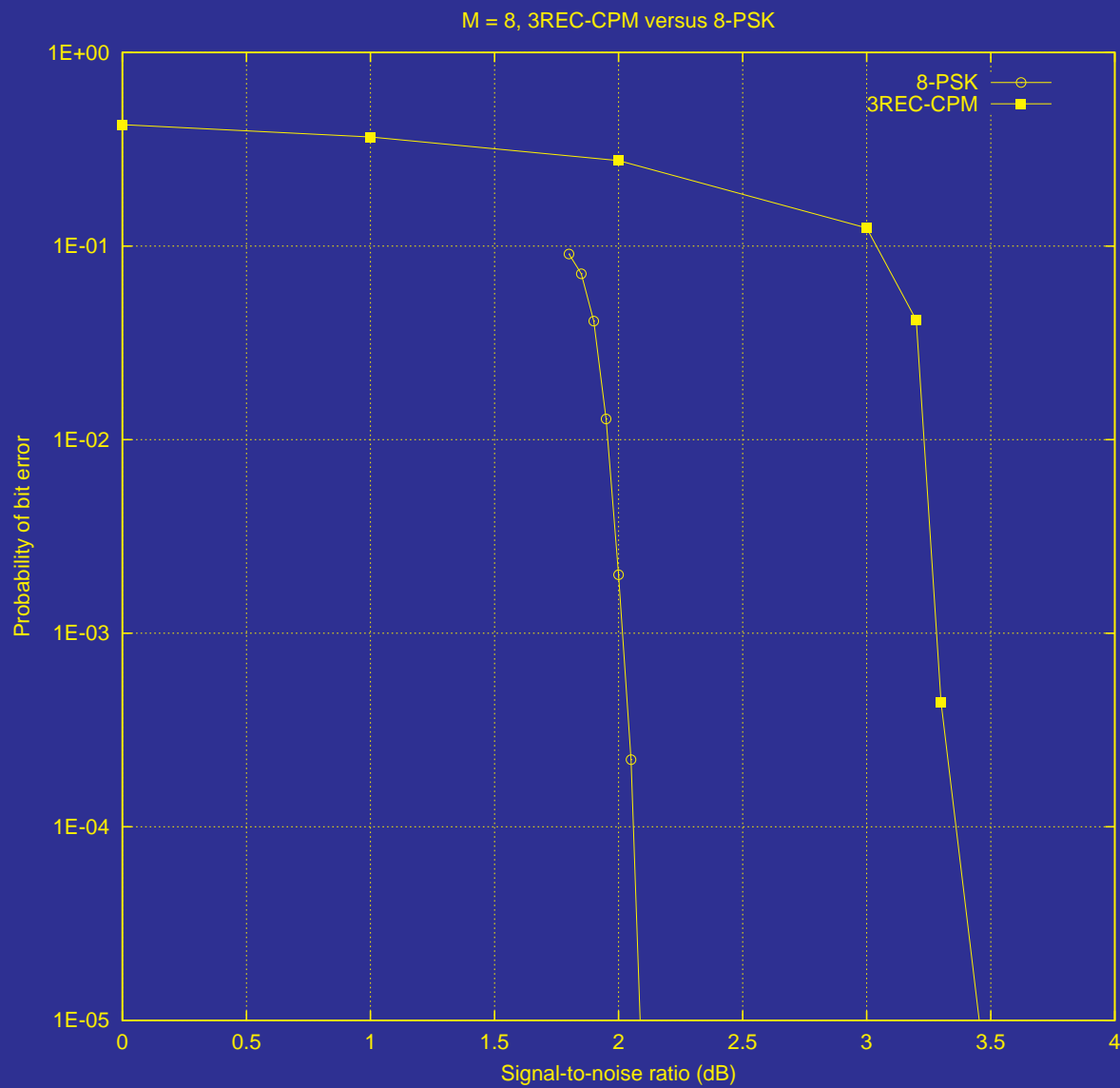
Performance of CPM Signaling

3RC Modulation, $M = 8$



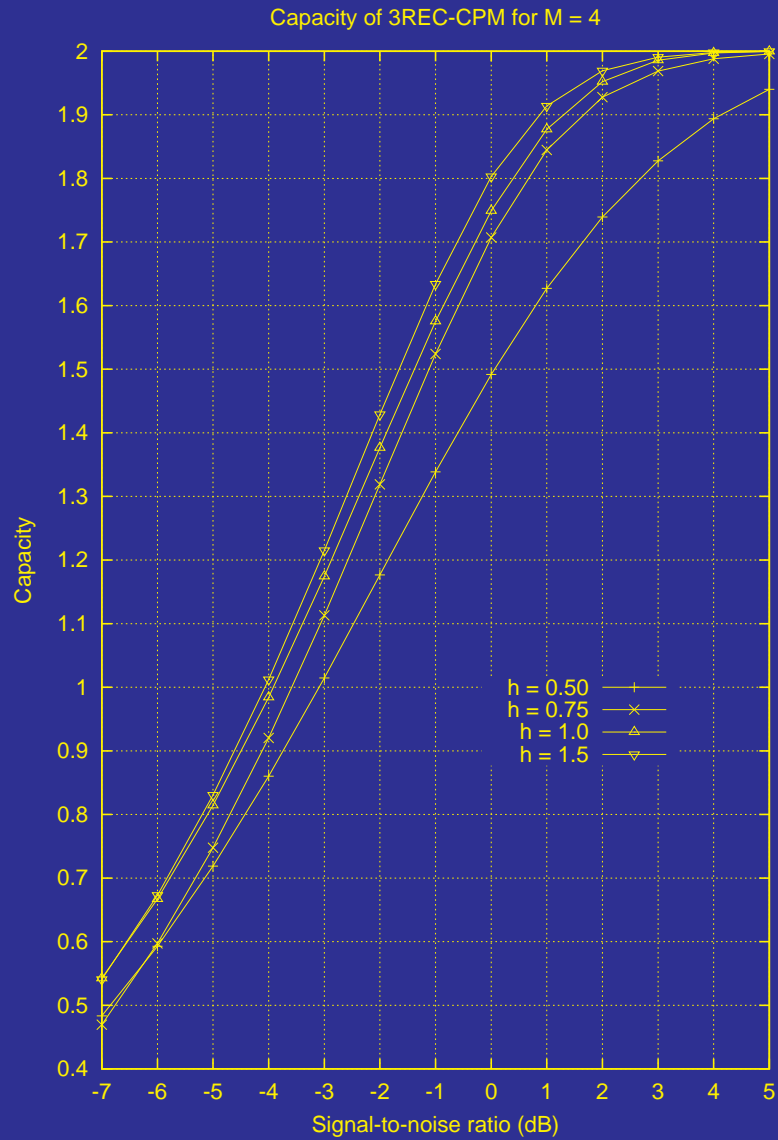
Performance of CPM Signaling

3REC Modulation, $M = 8$



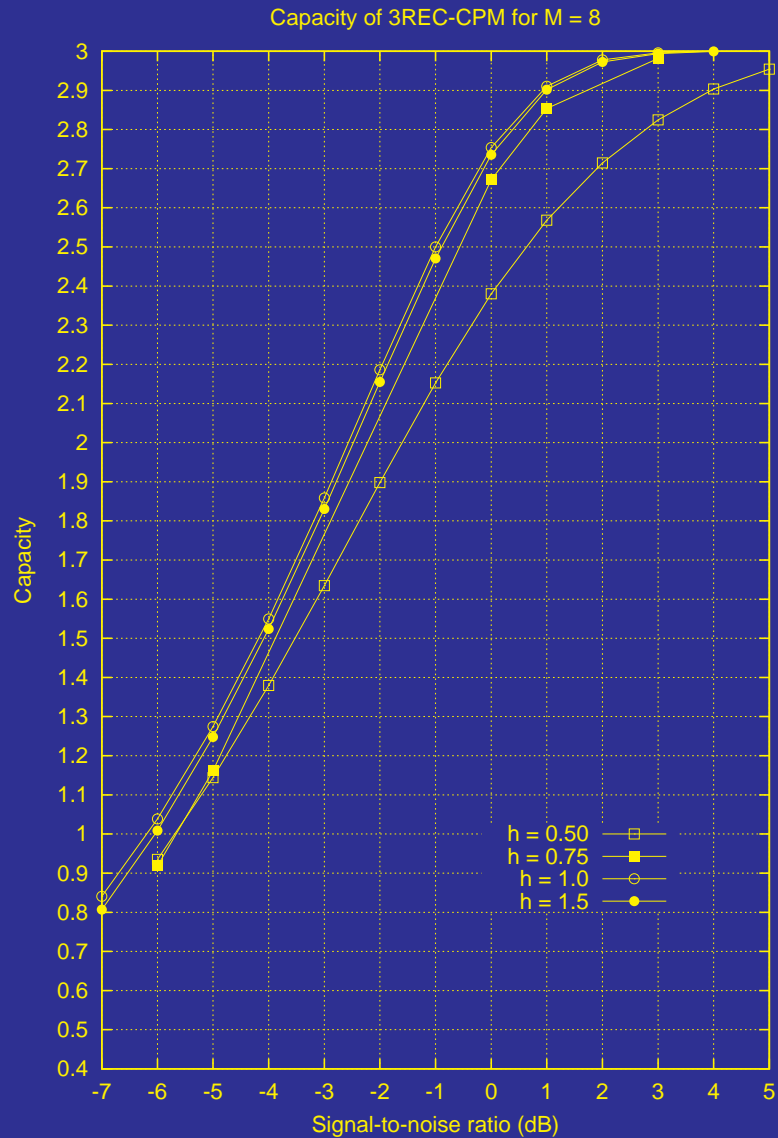
Capacity of CPM Signaling

3REC Modulation, $M = 4$



Capacity of CPM Signaling

3REC Modulation, $M = 8$



Performance vs Capacity

	Minimum SNR	SNR Required
3REC $M = 4$	-3.5 dB	×
3REC $M = 8$	-4.0 dB	3.5 dB
3RC $M = 4$	-3.0 dB	2.0 dB

Conclusions

- For $M = 8$, turbo-coded CPM schemes are as energy-efficient as M-PSK modulation.
- For $M = 4$, turbo-coded CPM schemes require about 1.2dB more SNR than M-PSK modulation.
- BICM
- The bandwidth-efficiency and energy-efficiency of CPM modulation can be traded by choosing h carefully. This is a current topic of research.
- Turbo-coded CPM schemes are still quite far from achieving capacity.