Performance of Multiband OFDM In IEEE UWB Channel Models

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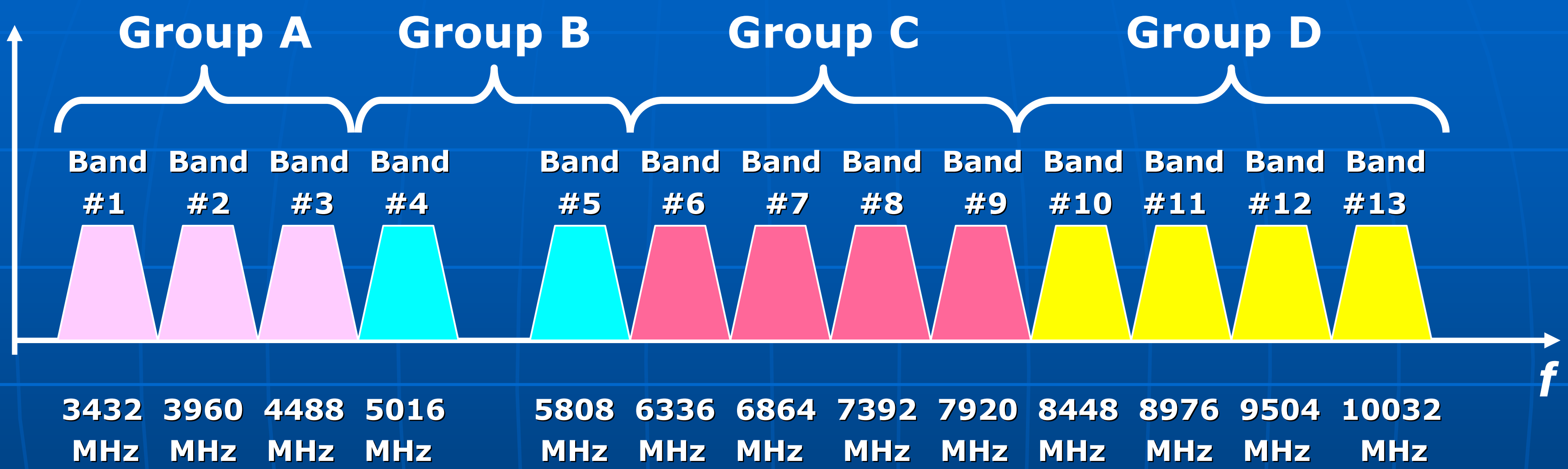
Purpose of The Study

- Investigate the performance of multiband-OFDM as a modulation technique for information transmission in the unlicensed band between 3.1 and 10.6 GHz.

Presentation Outline

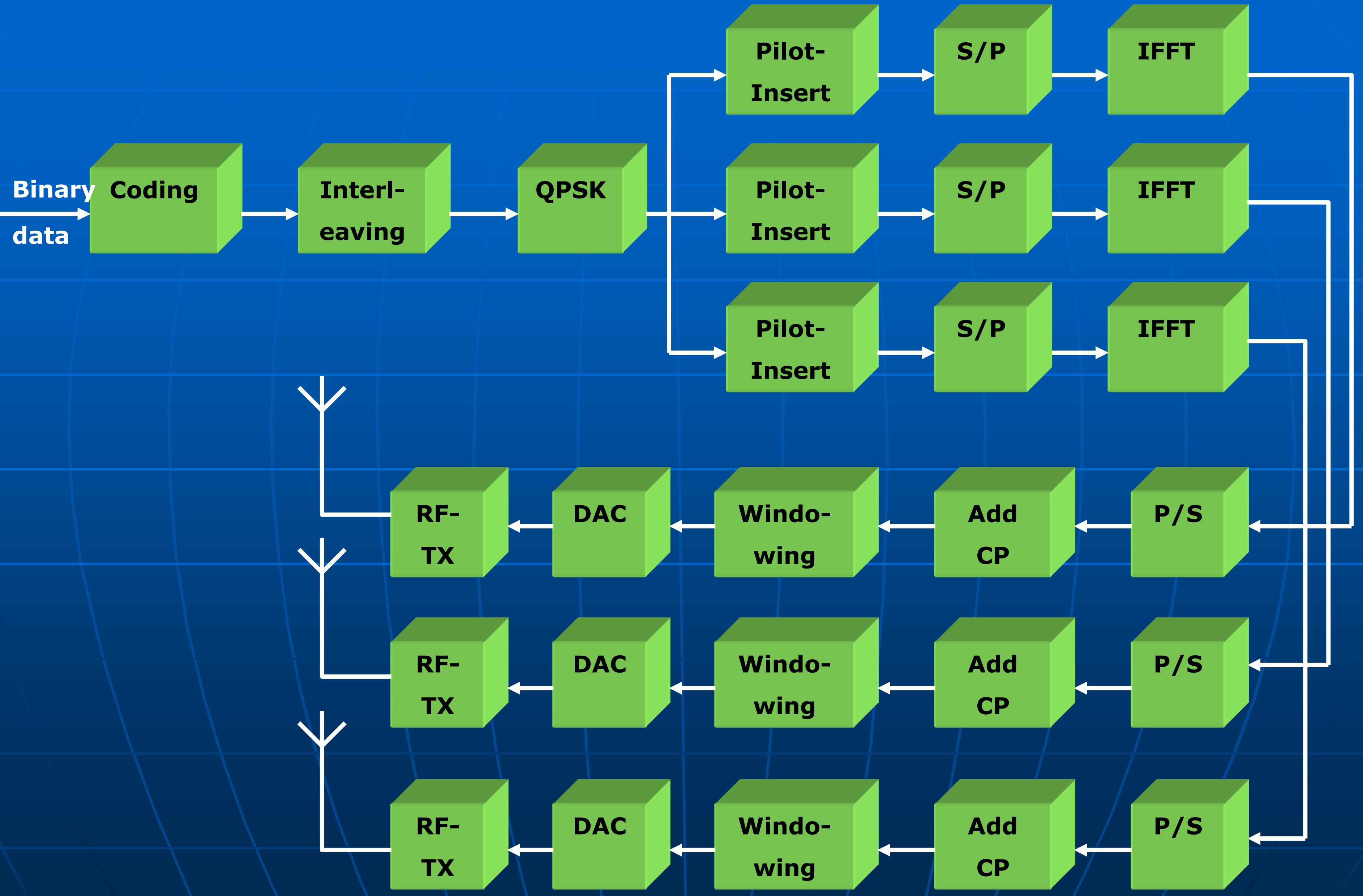
- Ultrawideband (UWB)
- The multi-band Approach
- Multi-band OFDM Transmitter
- System Parameters
- System Assumptions
- Channel Model
- Uncoded multi-band OFDM System Performance
- Coded multi-band OFDM system Performance
- Future Work

Multiband Approach



- **Group A**: 3.1-4.9 GHz. Assigned for 1st generation devices
- **Group B**: 4.9-6 GHz. Designated for future use
- **Group C**: 6-8.1 GHz. Intended for devices with improved SOP(Simultaneously operating piconets) performance
- **Group D**: 8.1-10.6 GHz. Designated for future use

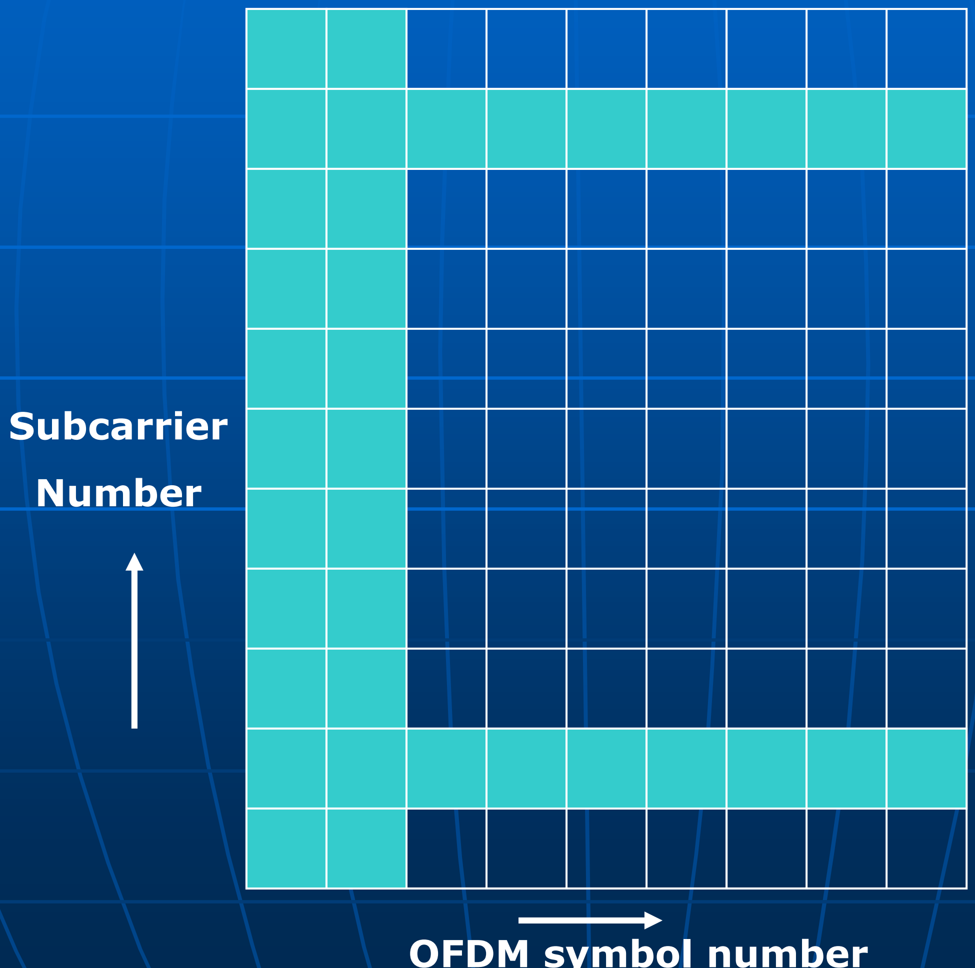
Multiband OFDM Transmitter



Pilot Distribution Pattern

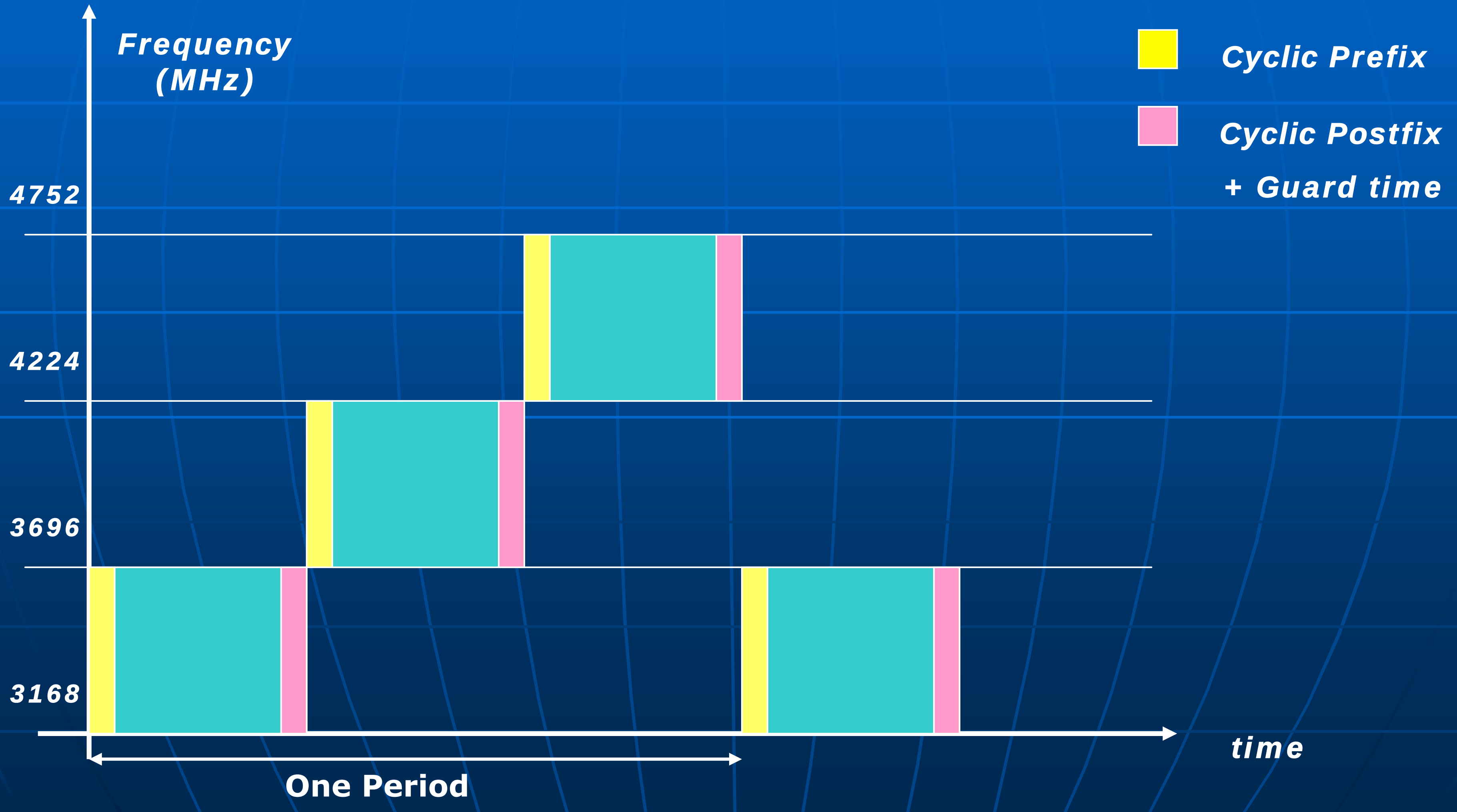
- **Channel is constant over the whole packet duration.**

  A convenient pilot distribution pattern:



Information Transmission

- **Only the first three bands are used i.e. Group A frequencies (3.1-4.9 GHz)**



System Parameters

Parameter	Value
fs: sampling frequency	528 MHz
N_{DS}: # of data subcarriers	100
N_{PS}: # of pilot subcarriers	12
N_{TS}: total # of subcarriers used	112
Δ_F: subcarrier frequency spacing	4.125 MHz (= 528MHz/128)
T_{FFT}: FFT/IFFT period	242.424 ns (1/4.125 MHz)
T_{GI}: guard interval duration (prefix+postfix duration)	60.6 ns (= 32 samples/528 MHz)
T_{GT}: guard time	9.47 ns (= 5 samples/528 MHz)
T_{SYM}: total OFDM symbol duration	312.5 ns ($T_{SYM} = T_{FFT} + T_{GI} + T_{GT}$

- Channel bit rate = 200 bits/312.5 ns = 640 Mbits/sec or 213.33 Mbits/sec/band
- packet length = 1024 bytes equivalent to 41 OFDM symbols

System Assumptions

- Perfect time and frequency synchronization are assumed at the receiver
- The transmitter’s and the receiver’s local oscillators are adjusted to use the same frequency at any time and assumed to be stable so that no phase noise is generated
- Troubles that result from hardware nonlinearity and distortion caused by antennas are disregarded
- The cyclic prefix is considered to be long enough so that no ICI and ISI problems are present

The receiver

- At the receiver, the inverse transmitter's operations are carried out
- A critical building block in the receiver is the channel estimation block

- Least Square estimation technique was implemented:

$$H_{LS} = \frac{Y}{X}$$

Y: the average of received two training symbols

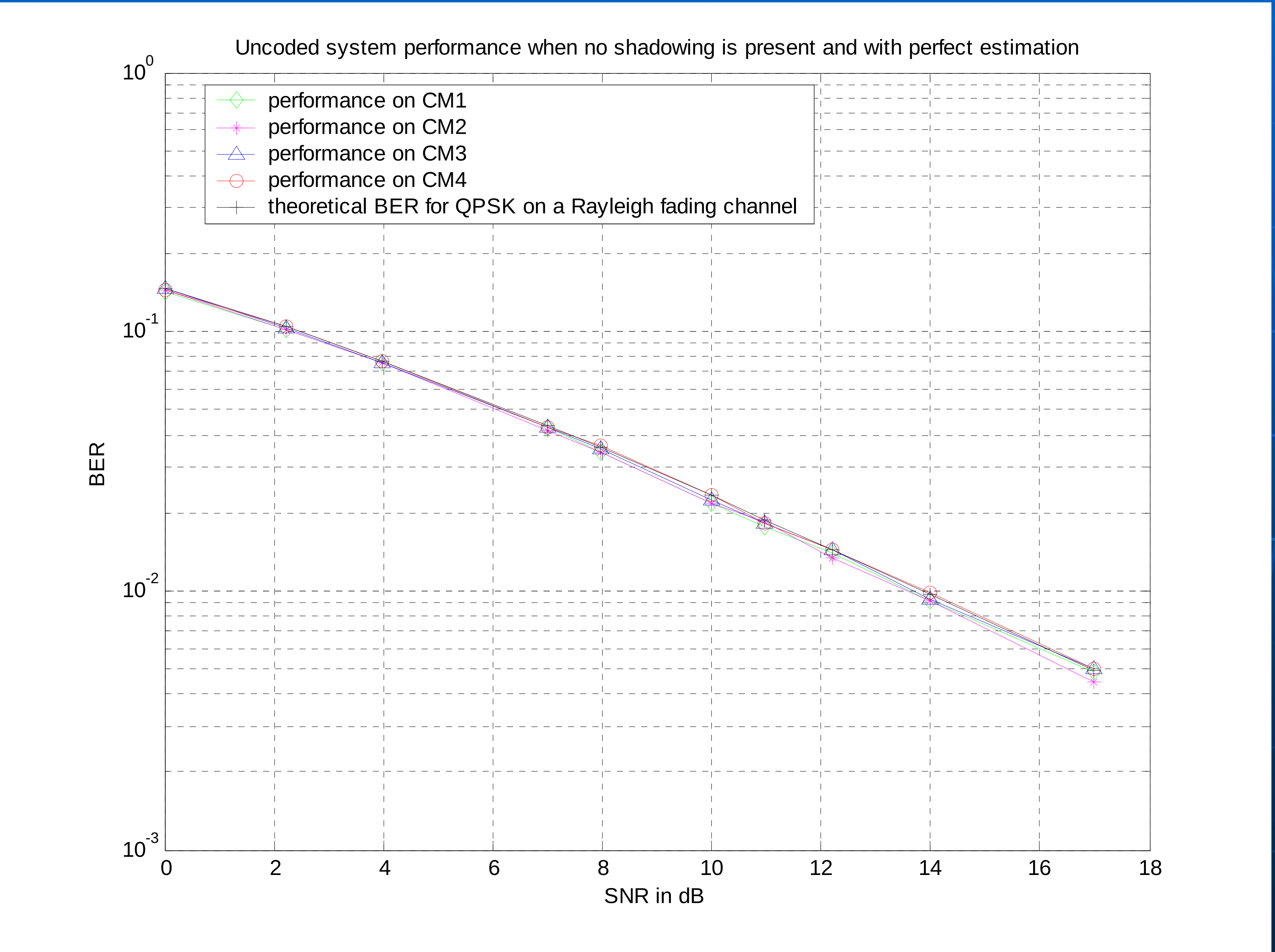
X: the transmitted information in the training symbols

Uncoded System Performance

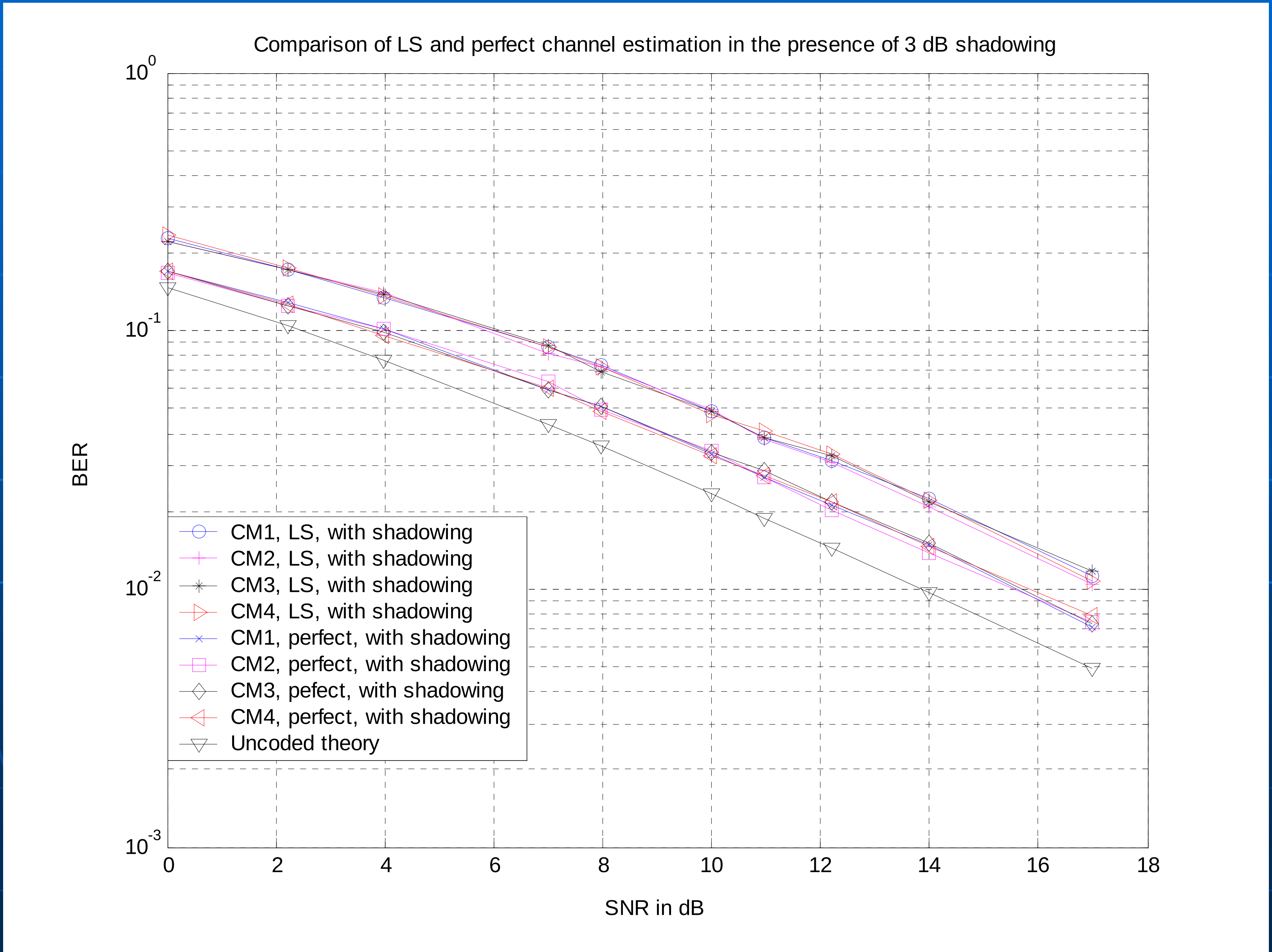
- Four cases were investigated:
  - Perfect channel estimation without shadowing
  - Perfect channel estimation with 3 dB shadowing factor
  - LS channel estimation without shadowing
  - LS channel estimation with 3 dB shadowing factor

Uncoded System Results

- **Perfect channel estimation, no shadowing:**



Uncoded System Results (cont°d)



Uncoded System Results (cont'd)

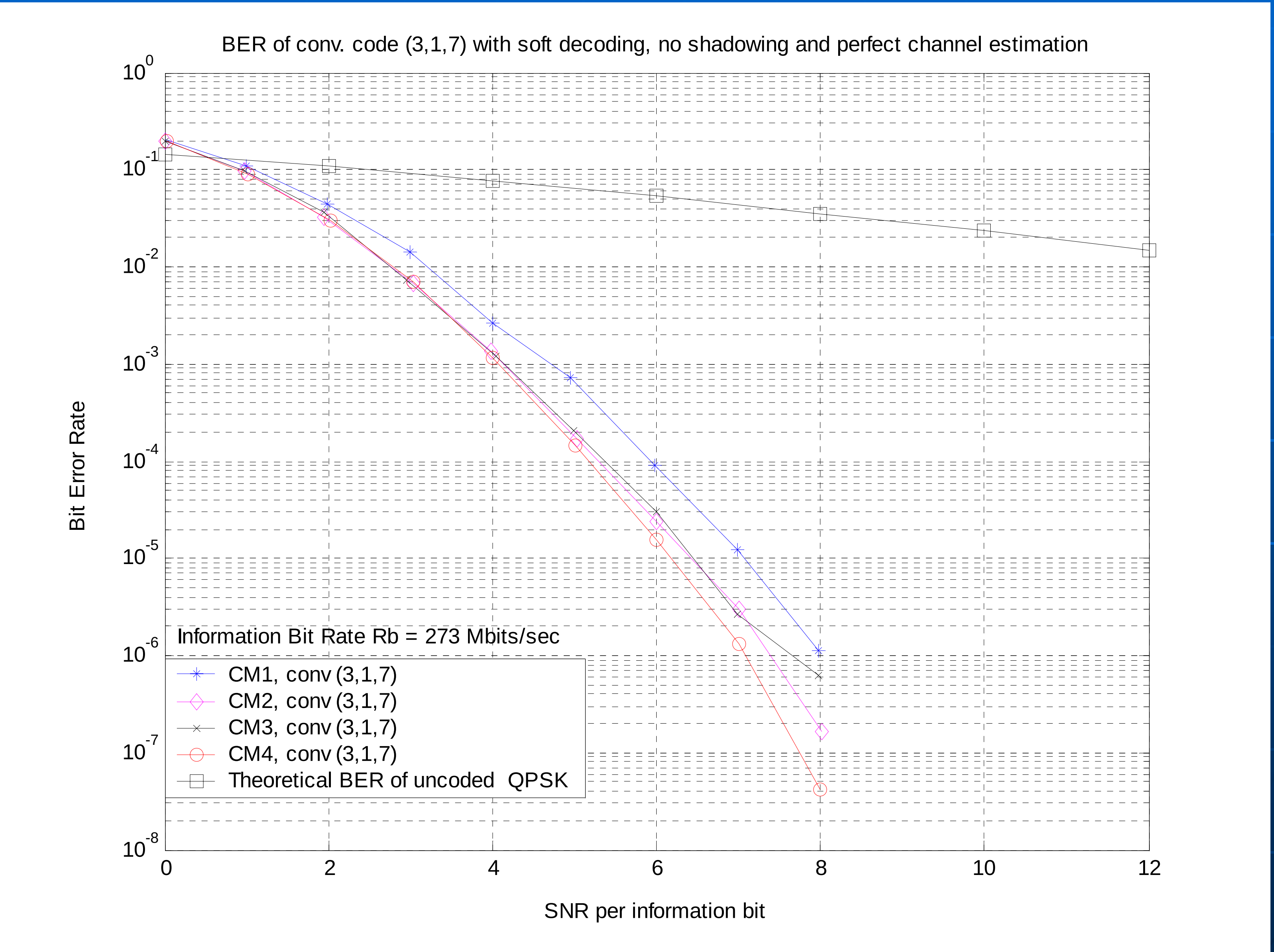
- With perfect channel estimation and without shadowing, the system performance is similar to that of a Rayleigh fading channel
- Including a 3 dB shadowing factor results in 1.5-2 dB shift to the right in the BER curve
- LS estimation results in 1.5-2 dB worse performance in the BER curve whether shadowing is present or not

Coded Multiband-OFDM System

- The performance of the coded multiband OFDM system was investigated using:
  - BCH codes with random interleaving
  - Optimum Distance Spectrum (ODS) convolutional codes with block interleaving (32x24 block interleaver)
  - BCH codes with hard decoding
  - ODS codes with soft decoding
  - Only case of perfect channel estimation and no shadowing
  - Only ODS shown here!

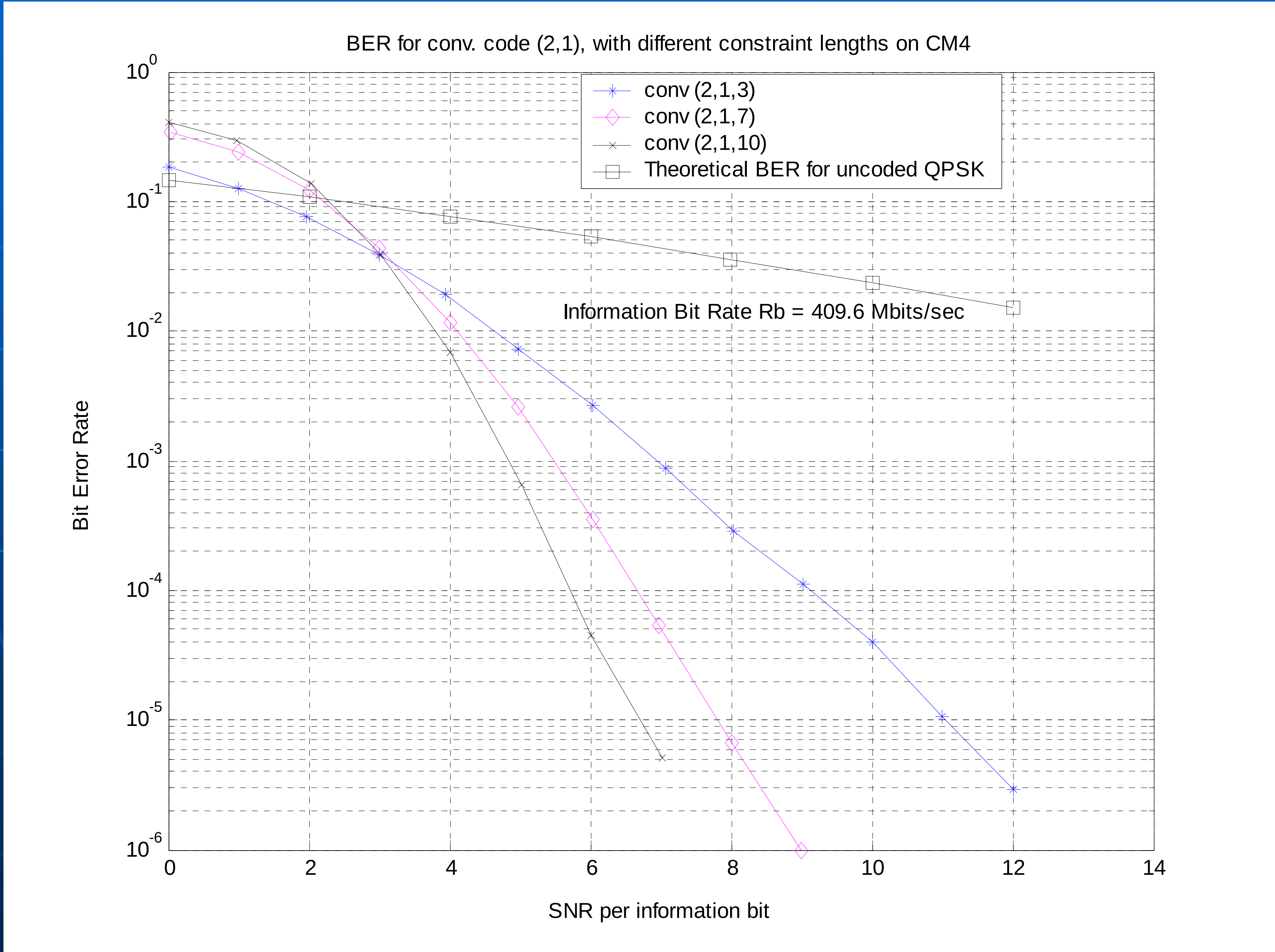
ODS Convolutional Codes

- **Conv (3,1,7) on CM1, 2, 3, 4**



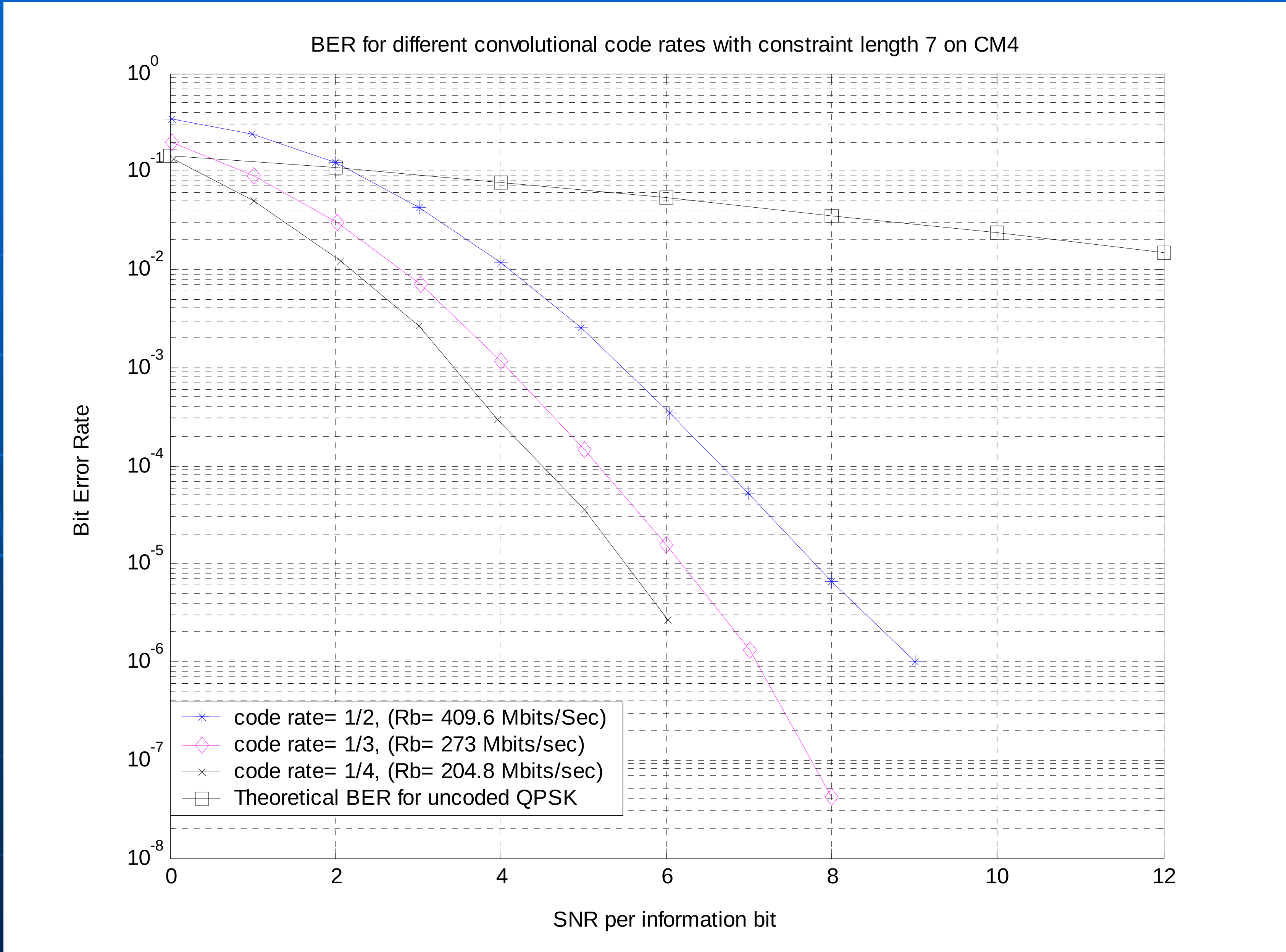
ODS Convolutional Codes (contºd)

- conv (2,1) with different k on CM4



ODS Convolutional Codes (cont^{d})

- conv. Codes with k=7 and different rates on CM4



Future Work

- Investigating with PSK and QAM with higher constellation size
- using different channel estimation techniques like MMSE
- Investigating with other FEC codes like Reed Solomon codes and punctured convolutional codes
- Interference from other pico-nets should be taken into account

Conclusions

- Multiband IR might be good for reasonably low rates when interpulse interference can be avoided
  - Should be studied in more detail with channel coding
- Multiband OFDM has great potential on UWB channels
  - Further optimization is needed

Forthcoming event

- Nordic Radio Symposium and Finnish Conf. on Wireless Communications (with PCC workshop) in Oulu August 16-18, 2004
  - 3 tutorials (UWB, MIMO, and Ad-hoc / sensor netw.)
  - 4 plenary speakers (Hagenauer, Fleury, van den Berg, Uusitalo)
  - http://www.cwc.oulu.fi/nrs04/

Sign up soon !

Questions, Remarks, Comments??