Interpolation Effects For OFDM Preamble

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Purpose:

To present XXXX

Interpolation Effects For OFDM Preamble

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Background

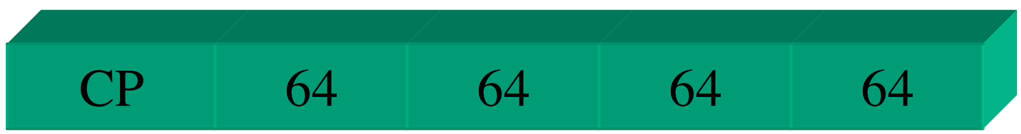
- Periodic structure simplifies Synchronization
- BW Efficiency dictates the use of a single OFDM symbol
- Solution : Use a single OFDM composed of identical sequences.
- Not all subcarriers are energized
- Interpolation is required.

Can interpolation do the job ?

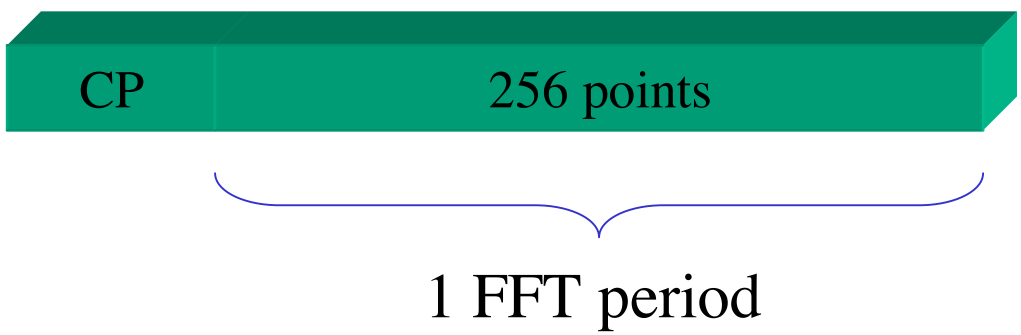
Schemes Considered

(a) 2x 128. Every second subcarrier energized. Current proposal.

(b) 4x 64. Every Fourth subcarrier energized. (Apu’s scheme.)



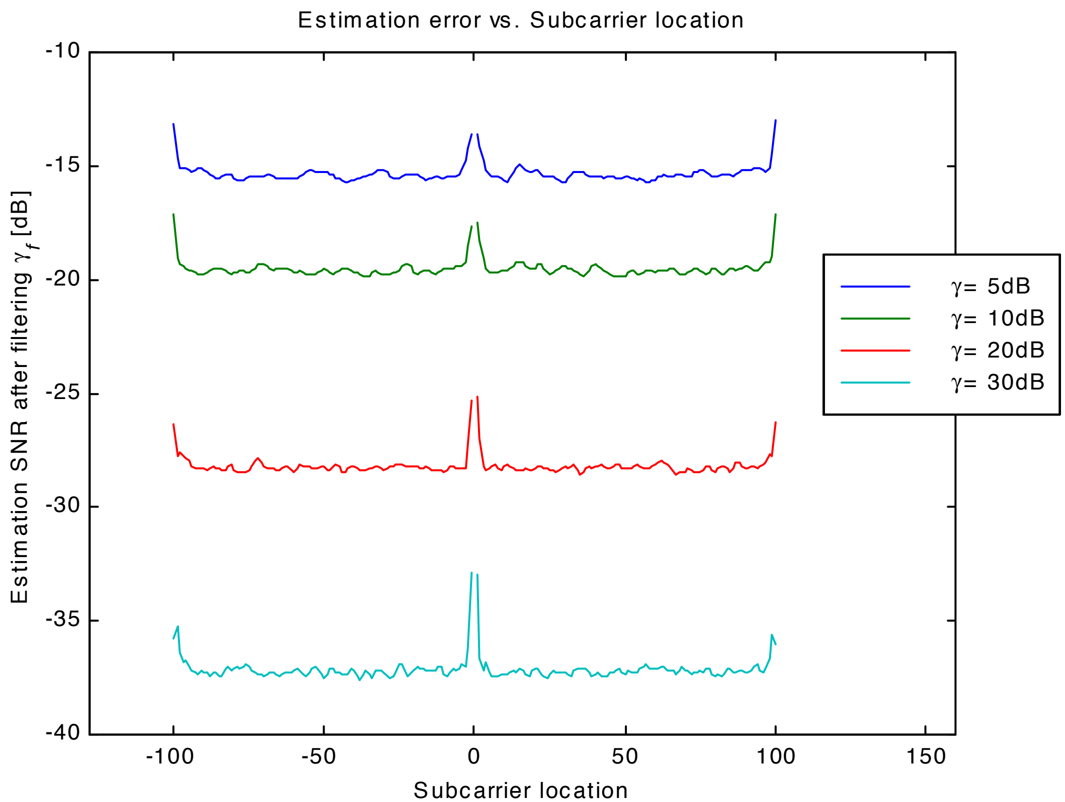
(c) 1x 256. All subcarriers energized. Used for reference.



Interpolation Technique

- Linear combination of subcarriers:
  - Estimate the response at missing subcarriers
  - Improve estimation at energized subcarriers.
- MMSE approach.
- SNR is assumed to be known.
- Special care at the band edge and near the DC.
- Timing estimation is required.

2 x 128 interpolation

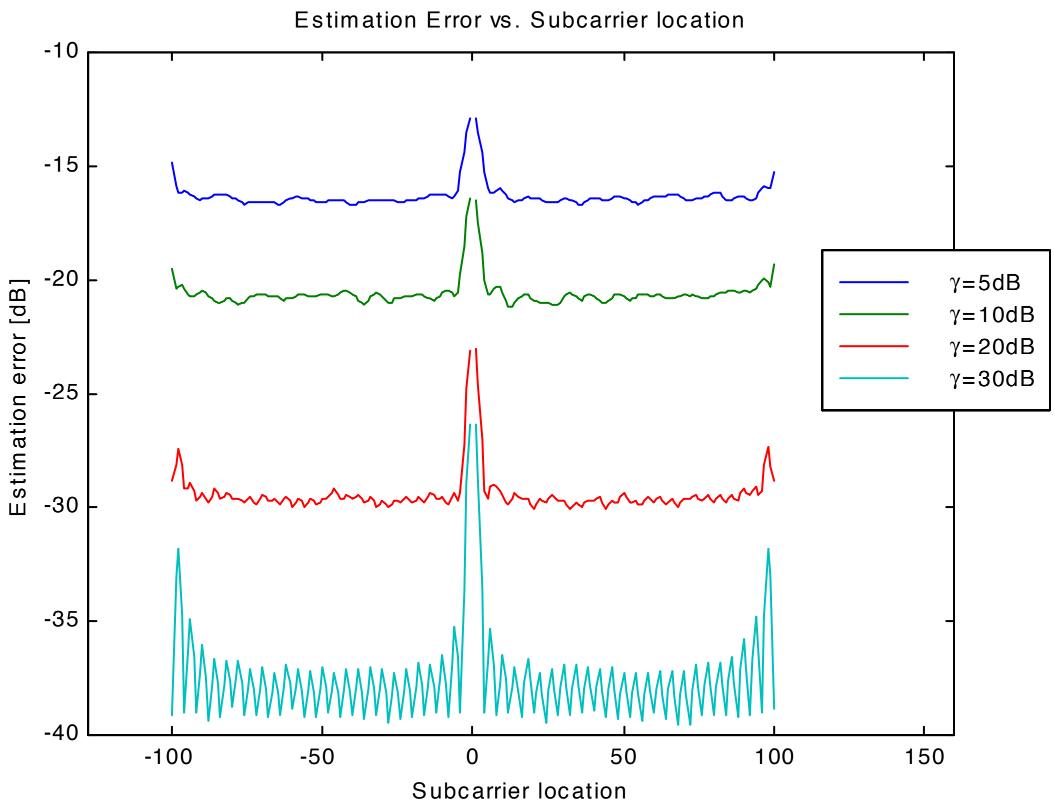


- Error vs.Sub carrier.
  - SUI 4 scaled to 8uS
  - 3.5 MHz
  - SNR=5…30dB
  - 3 dB preamble boosting

Improvement of 10…7dB.

Slight error increase near band edges.

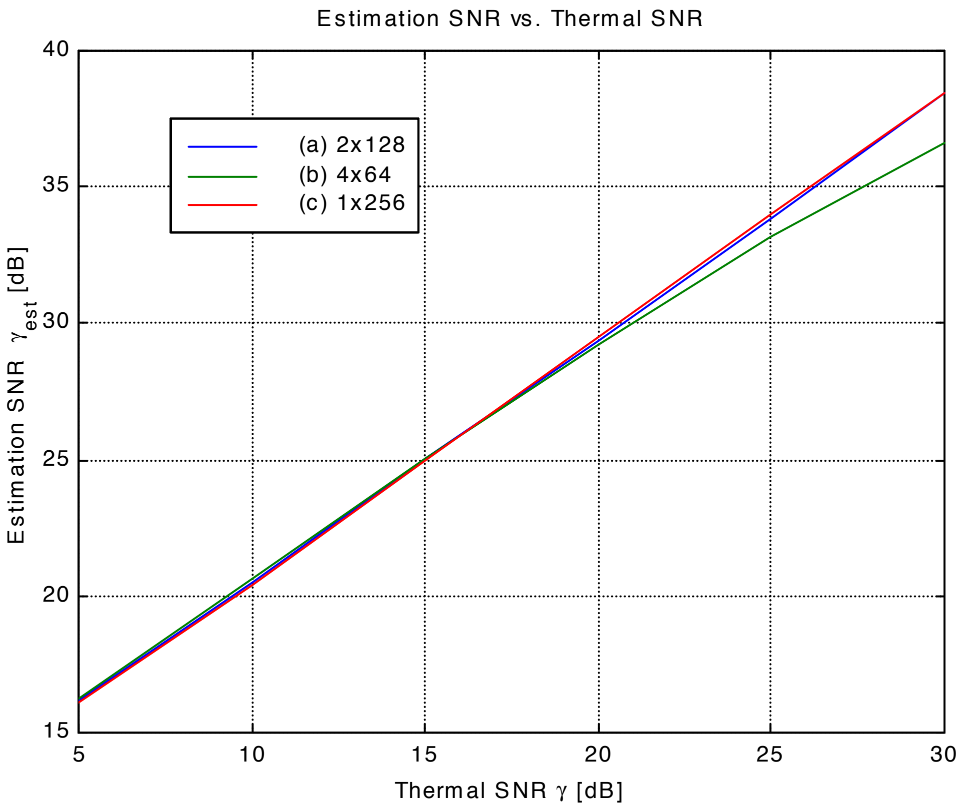
4x64 interpolation



- More error at DC
- More error at band edges.
- Difference between energized and non energized sub-carriers.

Estimation SNR

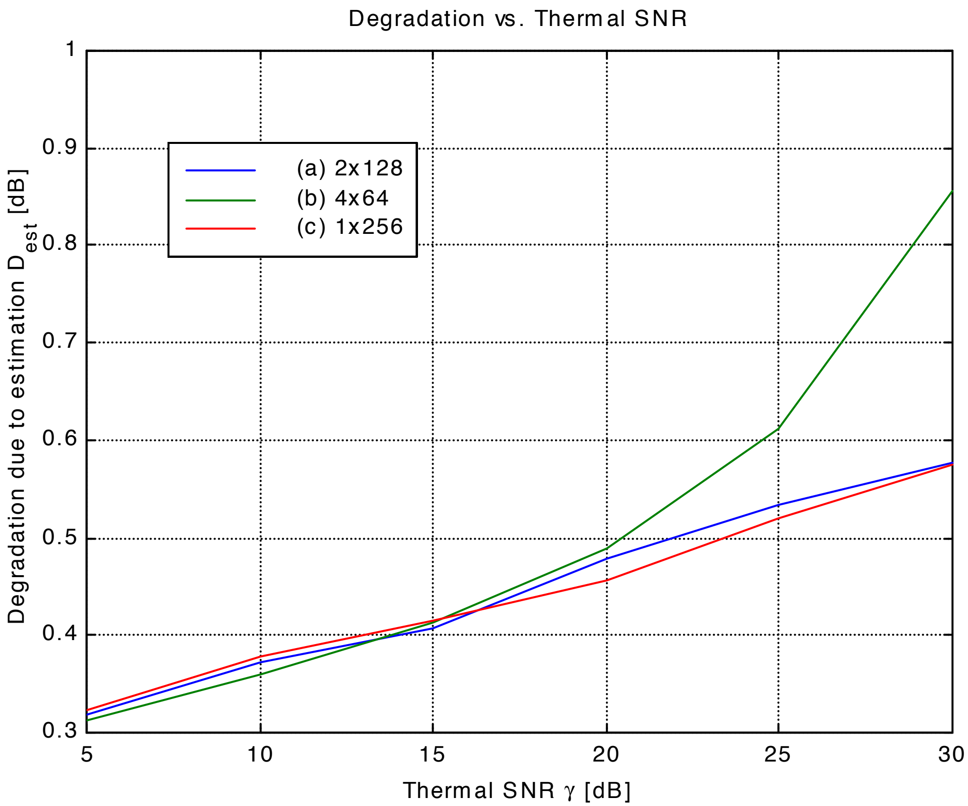
(3.5MHz SUI4 8uS)



- All schemes perform roughly equally.
- Slight loss for 4x64 at high SNR

SNR loss

(3.5MHz SUI4 8uS)



Detection noise:

hermal noise + Channel estimation noise

Degradation: How much SNR increase is needed ?

All schemes perform well.

0.4…0.9 dB degradation

Extension longer delay spreads

- What happens at longer delay spreads ?
  - Correlation between adjacent subcarrier is weakened.
  - Interpolation may fail
- Other degradation factor: Inter Symbol Interference
- Impulse may be longer than cyclic prefix.

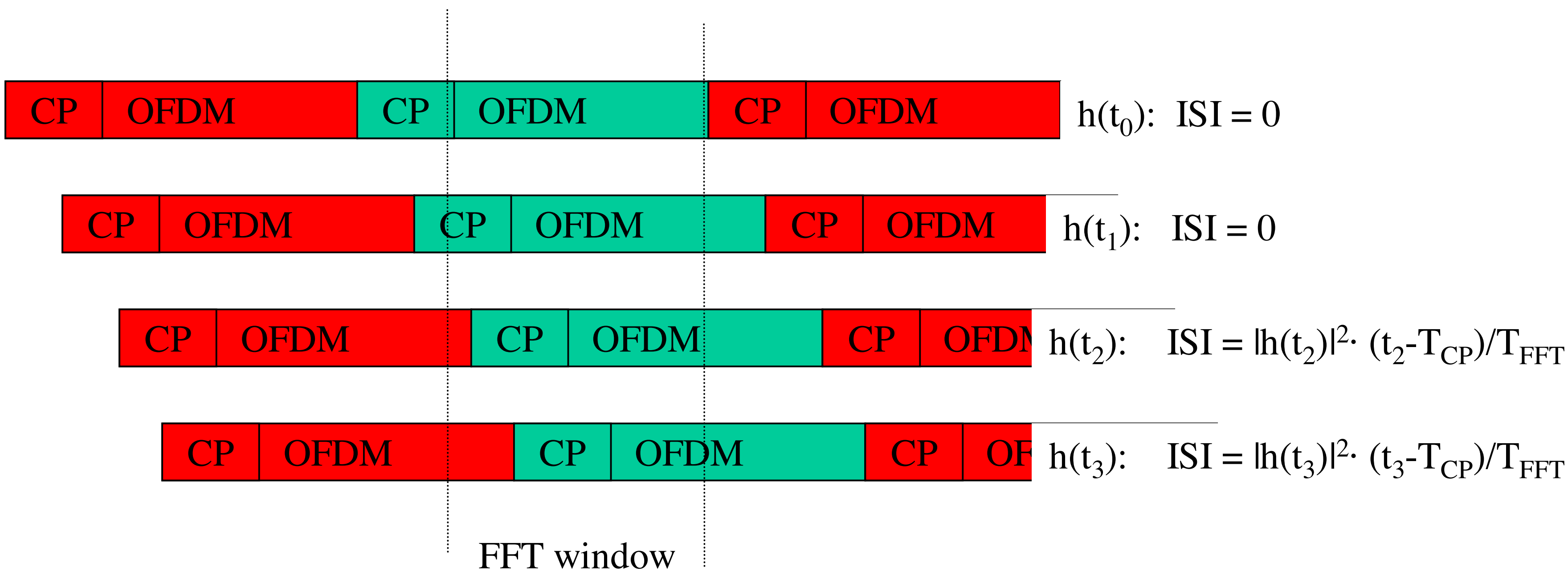
Long delay spreads

- Our preamble will be properly designed if the *estimation errors will not be the dominating factors*.

ISI calculation

An impulse response *h(t)*.

For each tap of *h(t):*



ISI calculation

- Assume an exponential profile

$$|h(t)|^2 \sim \exp(-t/T_{RMS})$$

'Back of an envelope' calculation:

$$\text{ISI noise} \cong T_{RMS}/T_{FFT} \exp(-T_{CP}/T_{RMS})$$

Where:

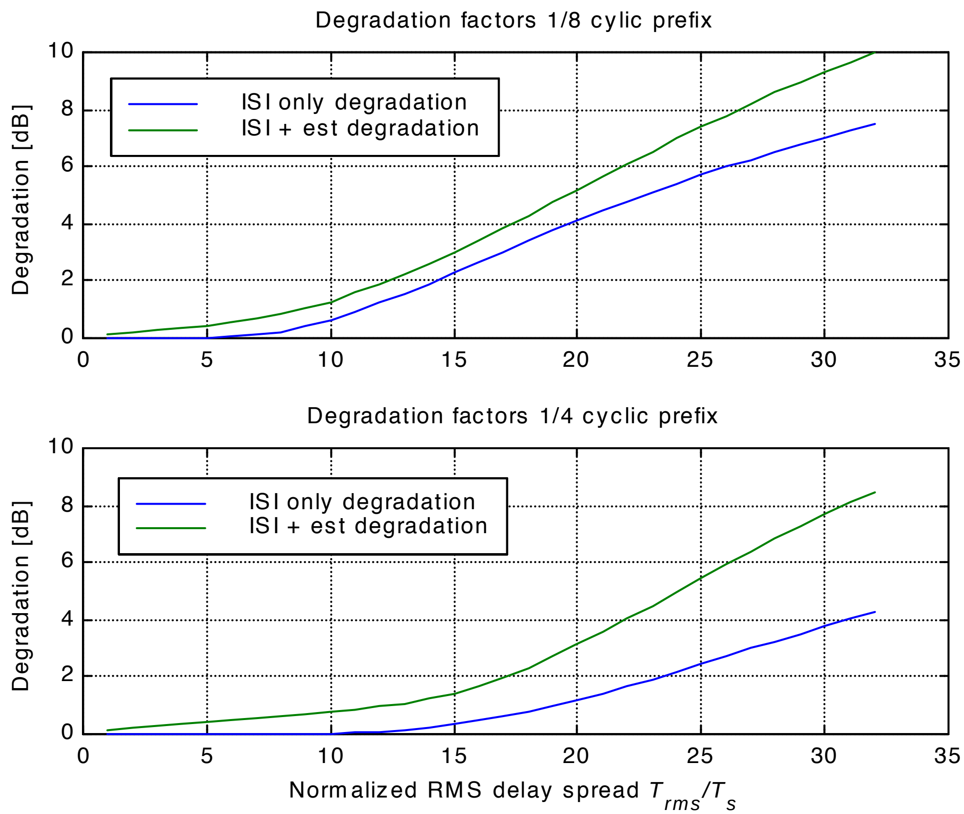
- T_{RMS} - RMS delay spread
- T_{FFT} - FFT duration
- T_{CP} - Cyclic prefix duration

Degradation due to ISI

- We compare:
  - The required SNR increase with ideal channel estimation (ISI noise only)

  To:
  - SNR increase with channel estimation (ISI noise + channel estimation).
- Results depend on T_{RMS} and T_{CP} as well as Interpolation scheme.

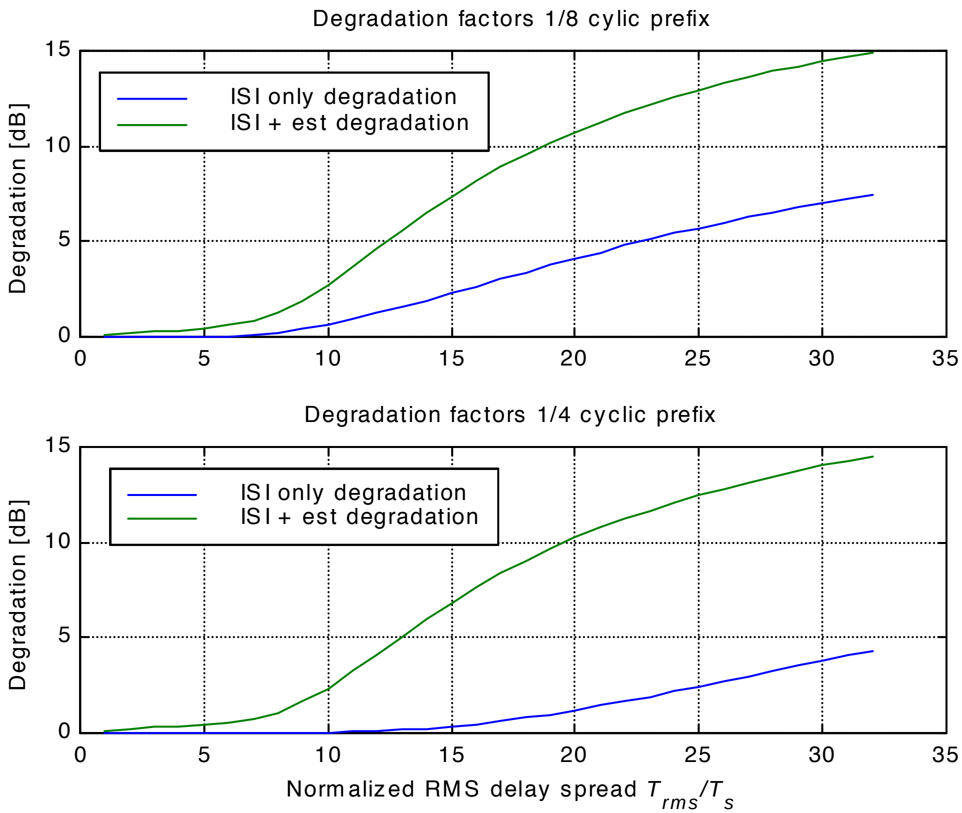
2x128 scheme.



- SNR=20dB.
- T_{RMS}=1…32 samples
- Results for 1/8 CP
  - 0.7dB Additional degradation.
- Results for 1/4 CP
  - 3 dB Additional degradation.

(For the range where total degradation <2dB.)

4x64 scheme



- Results for 1/8 CP
  - 5dB Additional degradation.
- Results for 1/4 CP
  - 8dB Additional degradation.

(For the range where total degradation <2dB.)

Conclusions

- All schemes performed well, for SUI#4 and 3.5MHz.
- For higher delay spreads:
  - 2x128 was not a dominant degradation factor.
  - 4x64 is a dominant degradation factor.
- Both will work, but 4x64 take things a bit too far.

Thank you.