

Interpolation Effects For OFDM Preamble

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Interpolation Effects For OFDM Preamble

Tal Kaitz

Alvarion (Breezecom)

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.

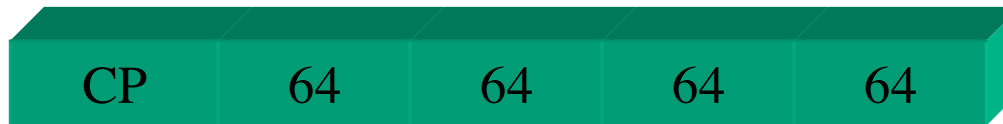
Can interpolation do the job ?

Schemes Considered

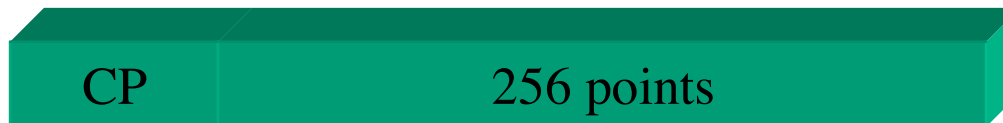
(a) 2x 128. Every second subcarrier energized. Current proposal.



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



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

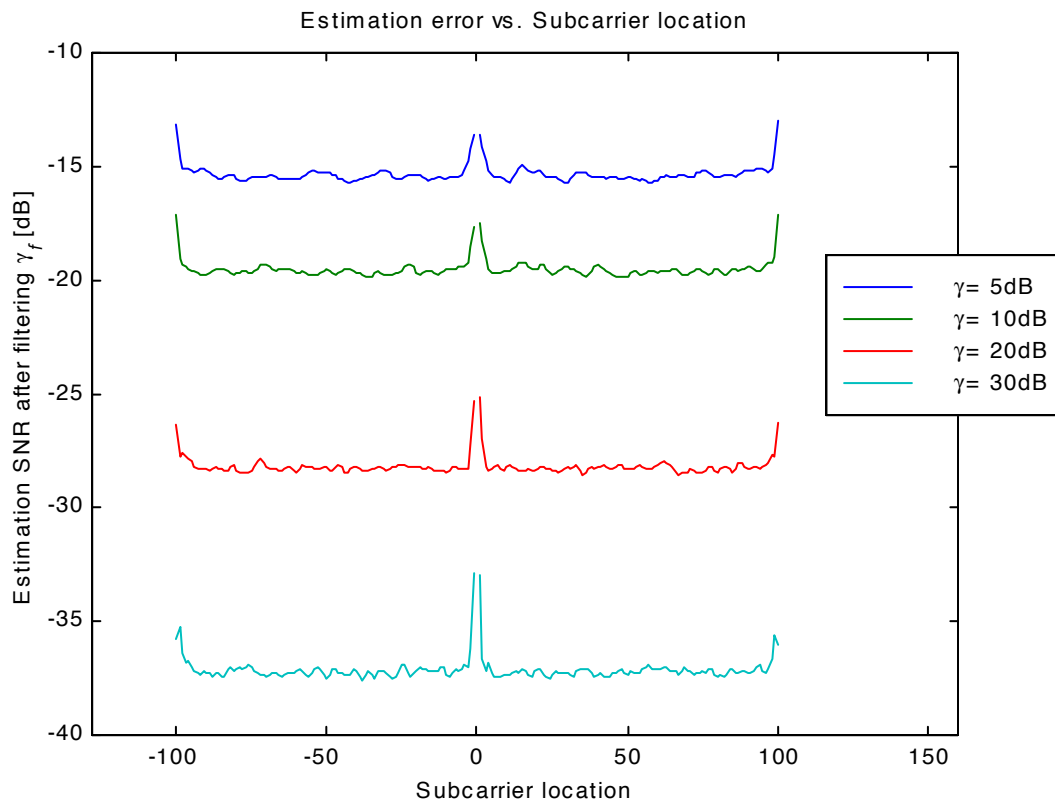


1 FFT period

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

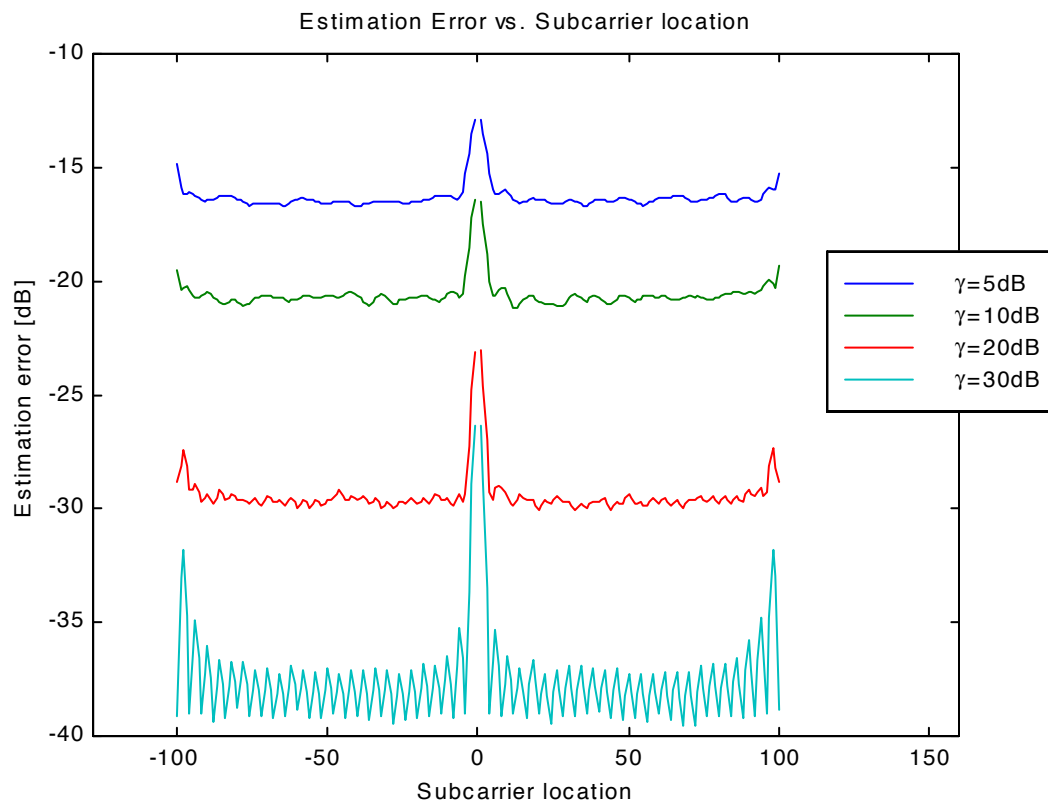


- Error vs. Sub carrier.
 - SUI 4 scaled to 8uS
 - 3.5 MHz
 - SNR=5...30dB
 - 3 dB preamble boosting

Improvement of
10...7dB.

Slight error increase
near band edges.

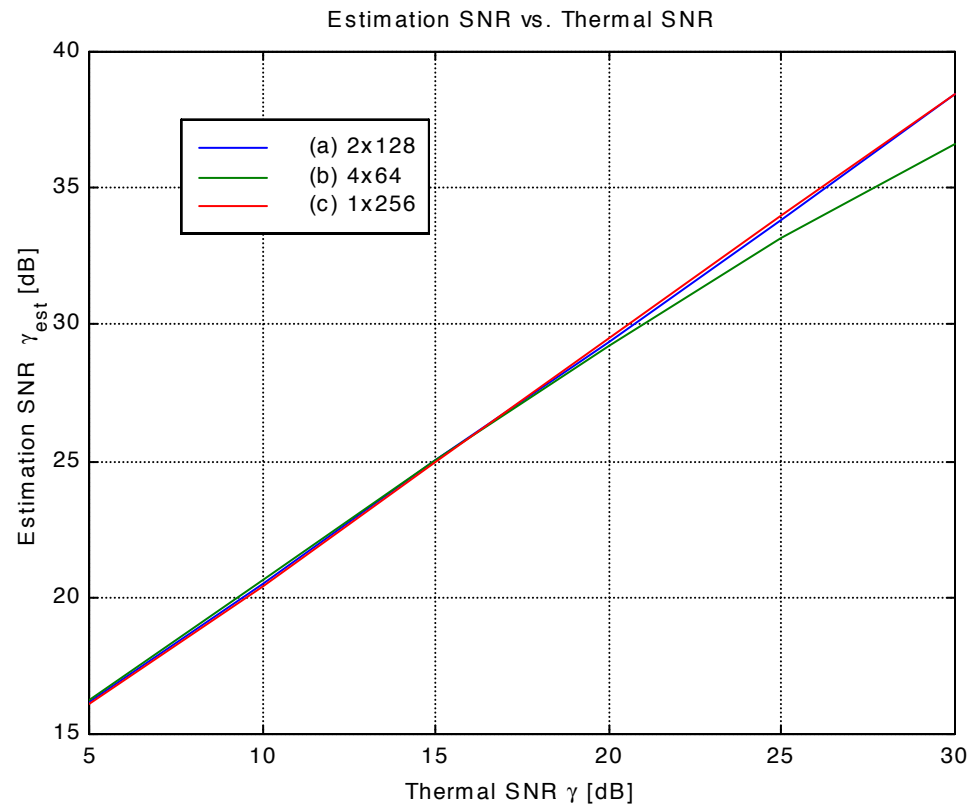
4x64 interpolation



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

Estimation SNR

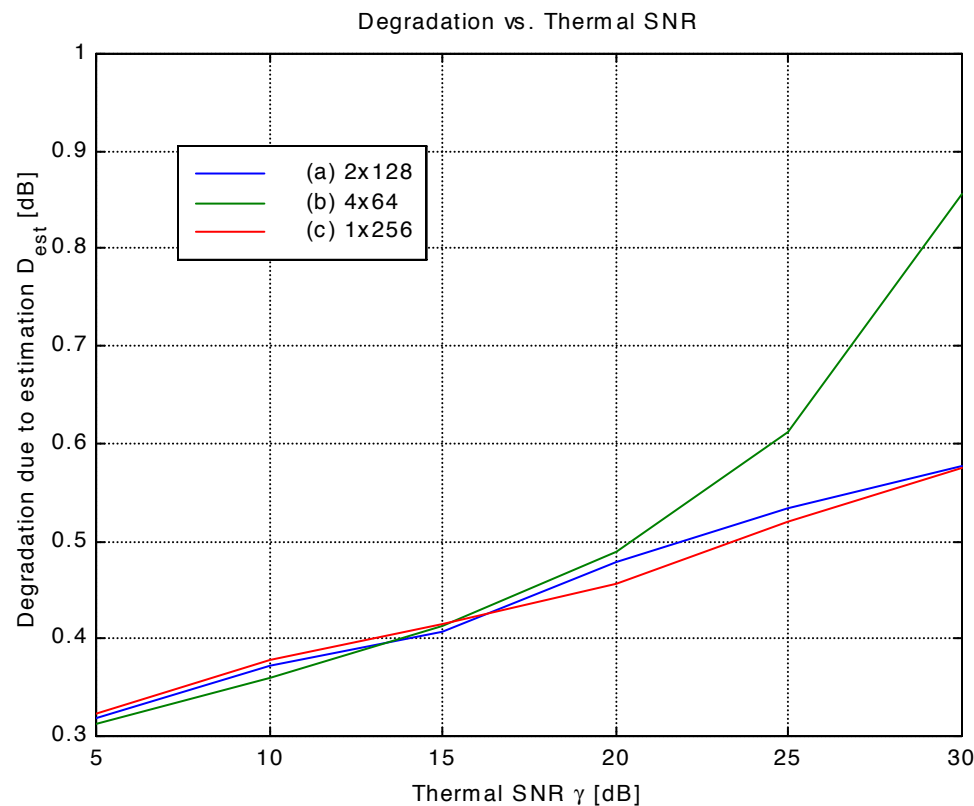
(3.5MHz SUI4 8uS)



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

SNR loss

(3.5MHz SUI4 8uS)



Detection noise:
thermal 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.

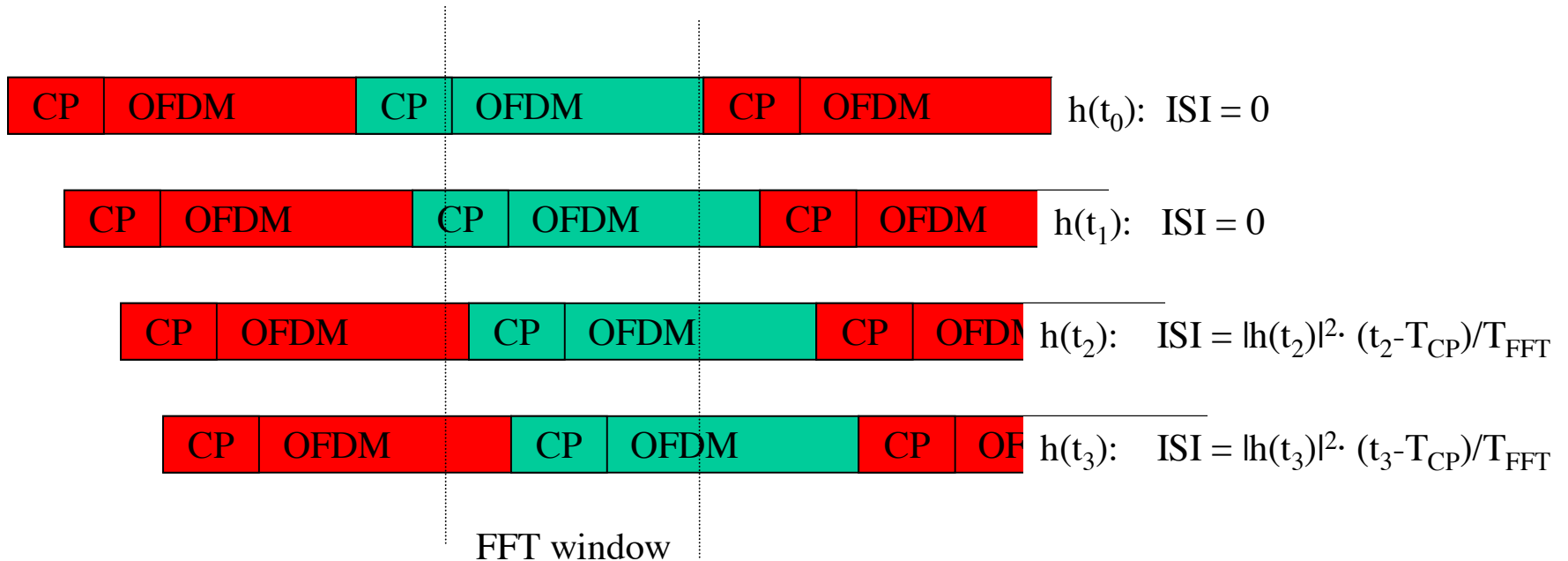
Long delay spreads

- 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:

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

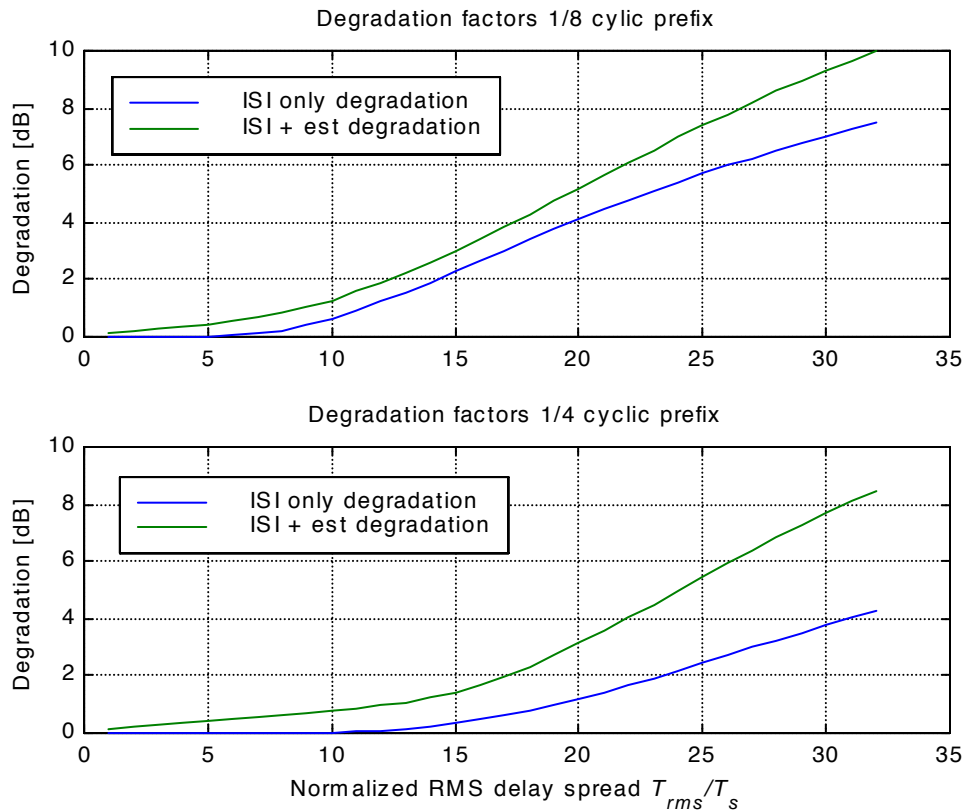
Where:

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

Degradation due to ISI

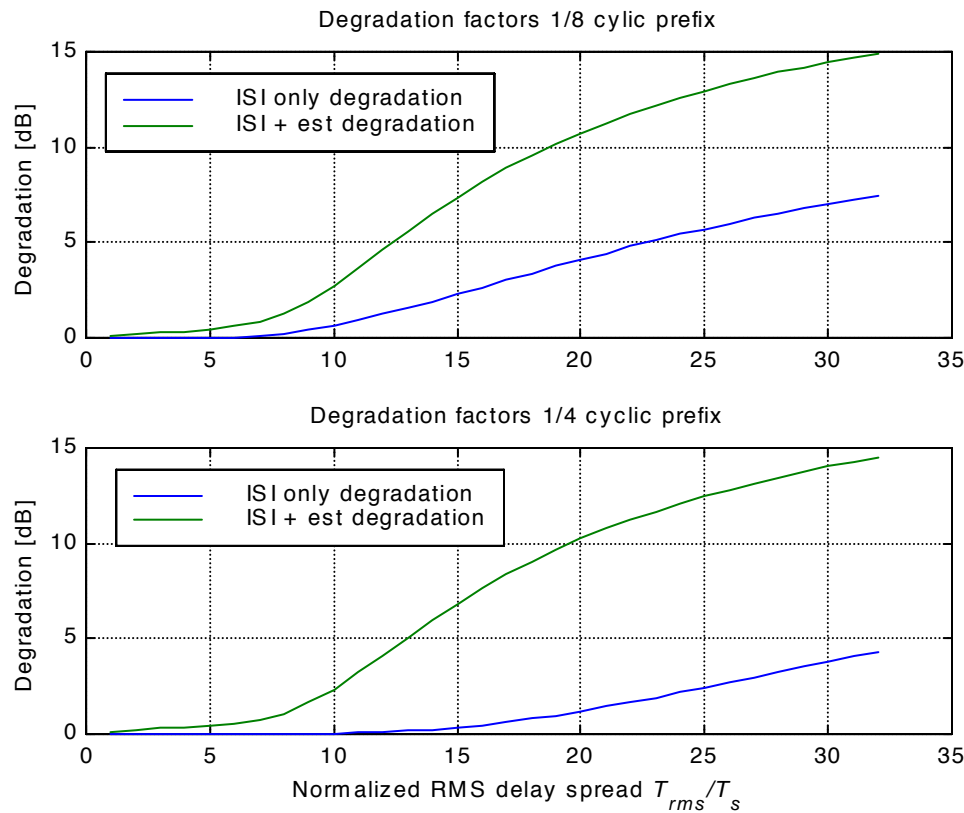
- We compare:
 - The required SNR increase with ideal channel estimation (ISI noise only)
- To:
 - SNR increase with channel estimation (ISI noise + channel estimation).
- Results depend on T_{RMS} and T_{CP} as well as Interpolation scheme.

2x128 scheme.



- SNR=20dB.
 - $T_{RMS}=1\dots32$ 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.