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Source(s)	Tal Kaitz Alvarion 21, HaBarzel Street Tel Aviv, Israel	Voice: Fax: mailto: tal.kaitz@alvarion.com	+972 54 22 56 48 +972 3 6456273
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Simulations Results for Subchannelization Mode

Tal Kaitz
Alvarion

Introduction

This document presents simulations results for the subchannelization mode.

Simulation Setup

The systems under test were those defined in 80216a-D6. Two systems were compared

a. 256 FFT OFDM mode, referred to as '***OFDM system***'.
b. Subchannelization mode using the subchannel #1. In the following this system is referred to as '***OFDMS system***'. Both systems are designed for the 3.5MHz bandwidth, and the sampling rate is 4MHz.

The performance of the system was evaluated under AWGN and multipath conditions. The multipath model was the SUI model defined in document IEEE802.16.3c-01/29r4. The channel was assumed to be static. A transmit frequency error of 100Hz was assumed. The ensemble average of the impulse responses was normalized to unity power.

For each simulation experiment at least 1000 packets were generated. The packets contained either 200 or 1000 bytes. For each packet, a different channel impulse response was generated. The simulation results include the effects of channel estimation and tracking, unless otherwise noted.

In the following, the SNR is defined as the ratio of the power spectral density (PSD) of the received signal to the PSD of the noise. **Thus, when subchannelization is employed, there is an additional power concentration gain of -10$\log_{10}$(fraction of BW), which is not shown in the graphs.** For example, when one out of four sub-channels is used, there is an additional 6dB gain.

Performance in AWGN

Figures 1-3 show the performance of the systems, under AWGN conditions. For QPSK and QAM16 the OFDMS system outperformed the OFDM system for PER<10^{-3}. This is related to the use of convulotional codes (CC) in the OFDMS relative to the concatenated CC and Reed-Solomon (RS) codes in the OFDM. The RS codes use a block length which is equivalent to one OFDM symbol. For low modulation orders this block is short and the coding gain of the resulting scheme is impaired.
For QAM64 system the OFDMS is better at PER<10^{-2}. For lower error probabilities the OFDM is better. This is also related to the differences in the coding schemes.

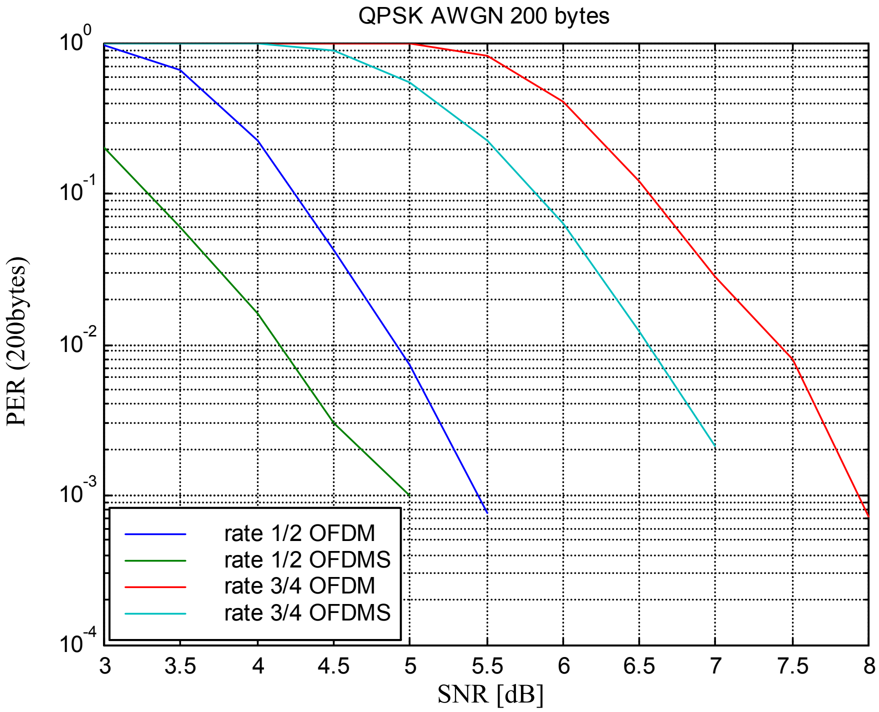

Figure 1 SNR vs. PER for QPSK in AWGN channels (200 B packets)

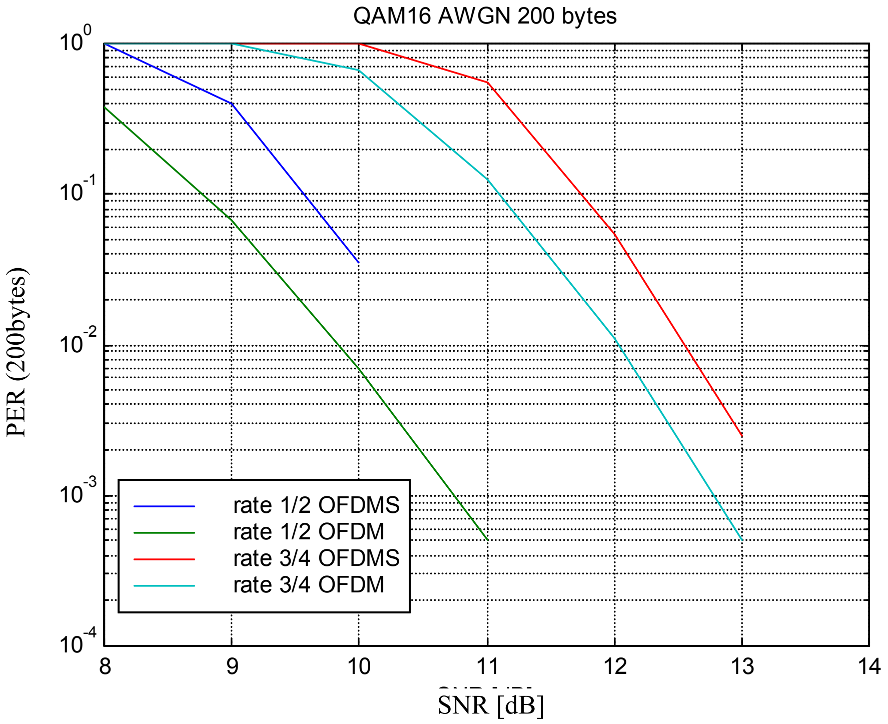

Figure 2 SNR vs. PER for QAM16 in AWGN channels (200B packets)

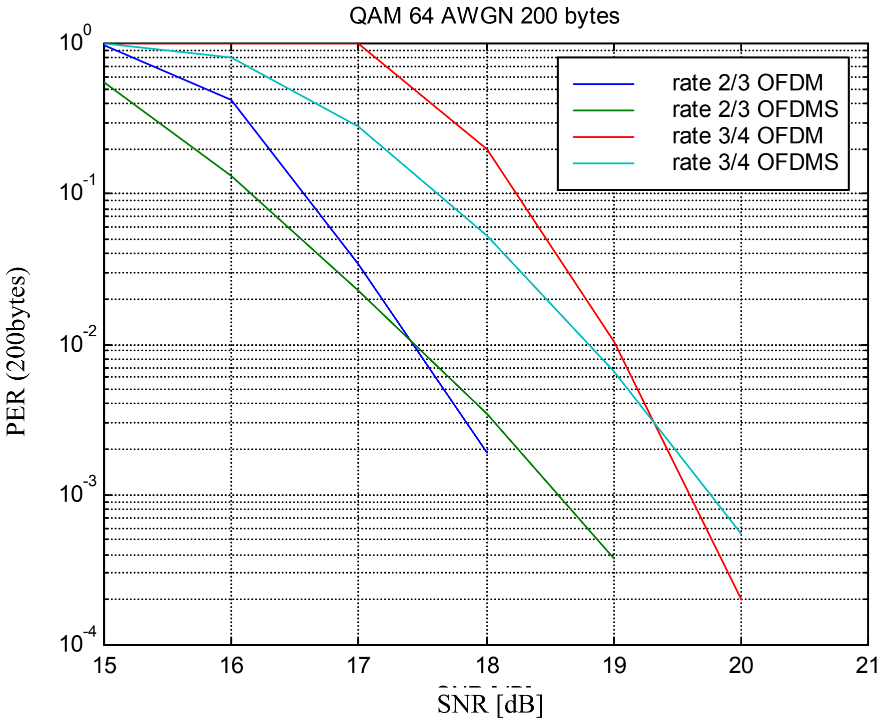

Figure 3 PER vs. SNR for QAM64 in AWGN channels (200B packets)

Performance in Multipath

Figures 3-6 show the performance on SUI channels. For QPSK (Figure 4) under SUI 5 conditions, the OFDMS scheme is better, though both the OFDM and OFDMS show an error floor.

Figure 5 shows the performance of QAM16 rate ½ in SUI3 and SUI4 channels (with directional antennas). At PER of 10^{-2} the OFDM and OFDMS schemes were equivalent.

Figure 6 shows the performance of QAM64 rate ½ in SUI3 and SUI4 channels (with directional antennas). At PER<10^{-3} the OFDM scheme was better by 0.5dB. For PER=10^{-3} the difference is about 1dB. For the case of omni directional antennas, the advantage of the OFDM grows to 2dB.

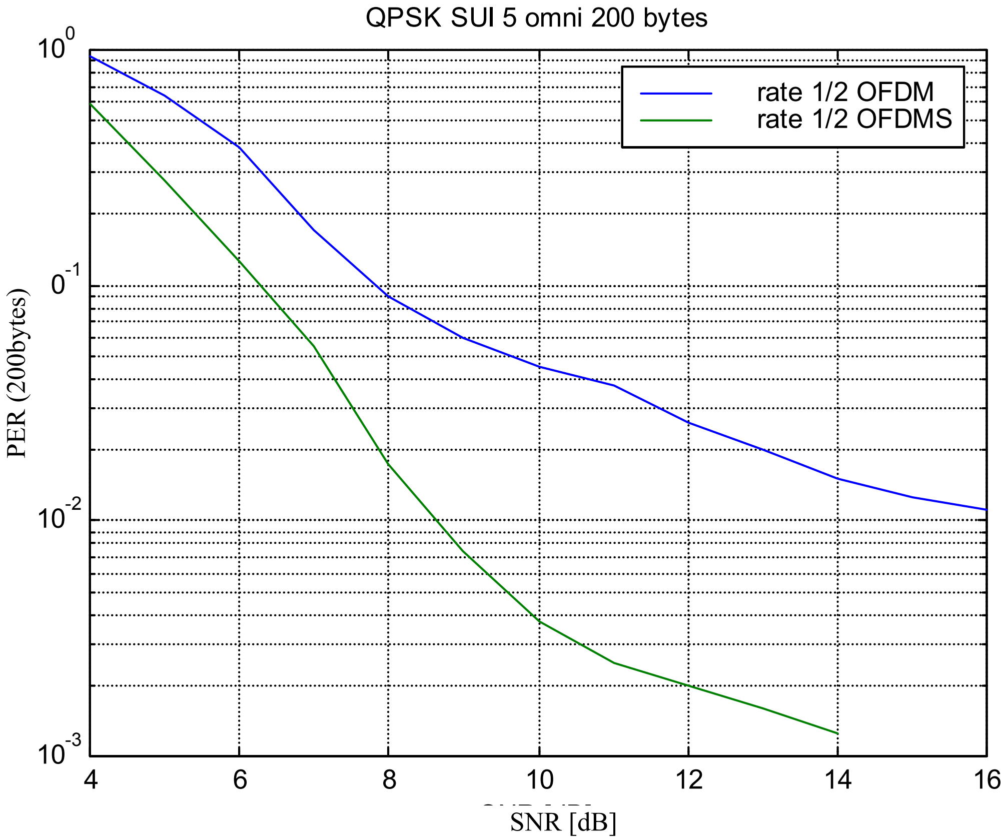

Figure 4 PER vs SNR for QPSK rate 1/2 on SUI5 channels (200B packets)

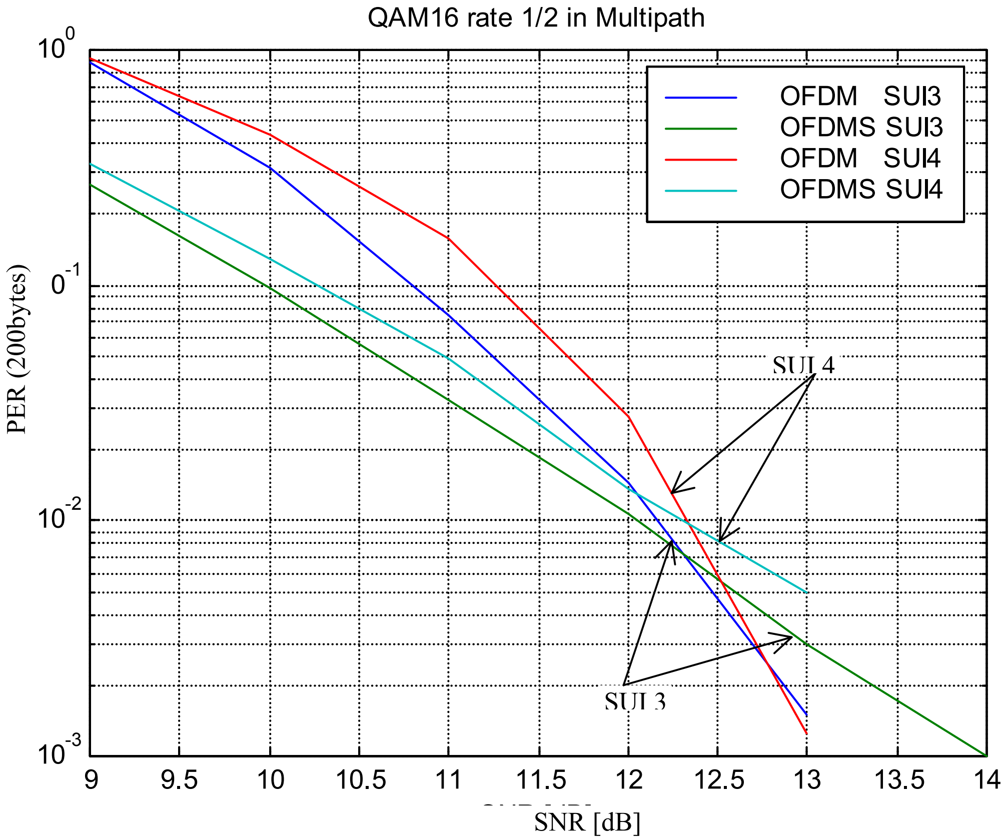

Figure 5 PER vs. SNR for QAM16 rate ½ in SUI3/4 Channels (200 packets)

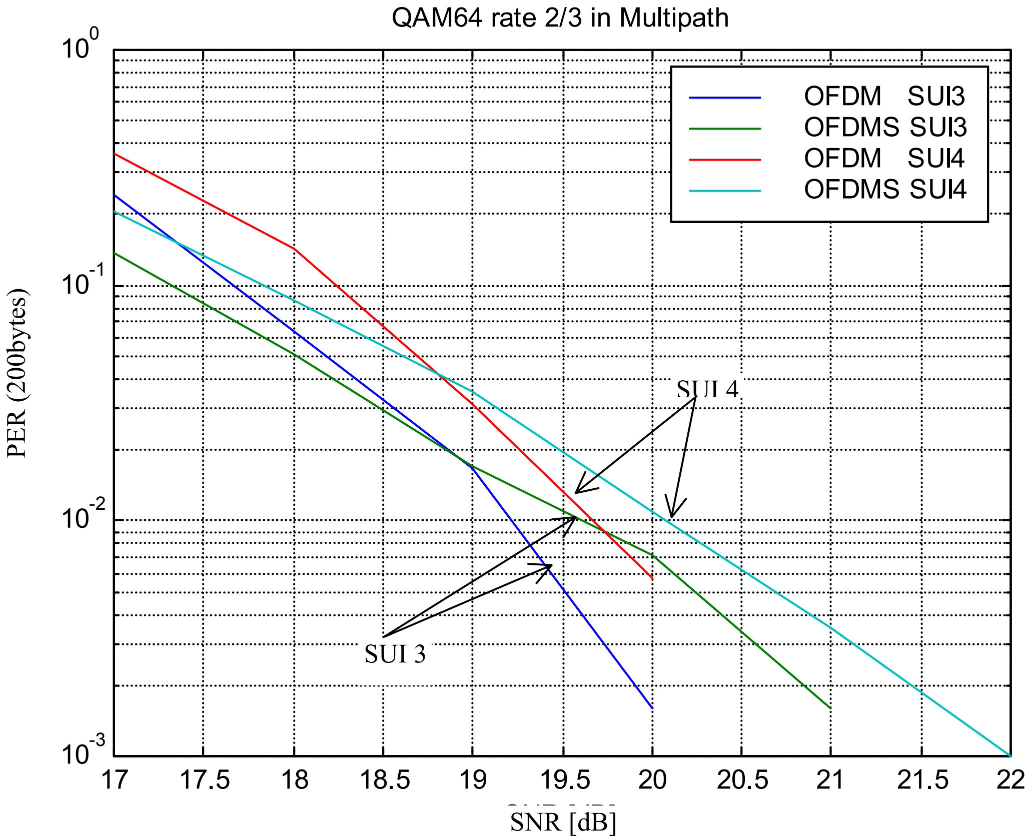

Figure 6 PER vs SNR for QAM64 rate 2/3 in SUI3/4 channels (200B packets)

Effects of Channel Estimation and tracking

In this section, the effects of channel estimation and tracking are considered. Figure 7 shows the performance of the OFDMS system for QAM64 rate 2/3 in AWGN channel when:

a. Both phase/ tracking and channel estimation are employed .
b. Only channel estimation is employed. The frequency error is assumed to be known.
c. The Channel State Information (CSI) is provided externally.

Phase tracking was performed using decision aided techniques. This proved to be nontrivial and it is recommended to increase the number of pilots in the OFDM/OFDMS modes in order to allow robust pilot aided tracking,

It can be seen that channel estimation caused a degradation of about 0.8dB. This is also the case of the OFDM system (Not shown). The phase tracking incurred an additional degradation of 0.4dB.

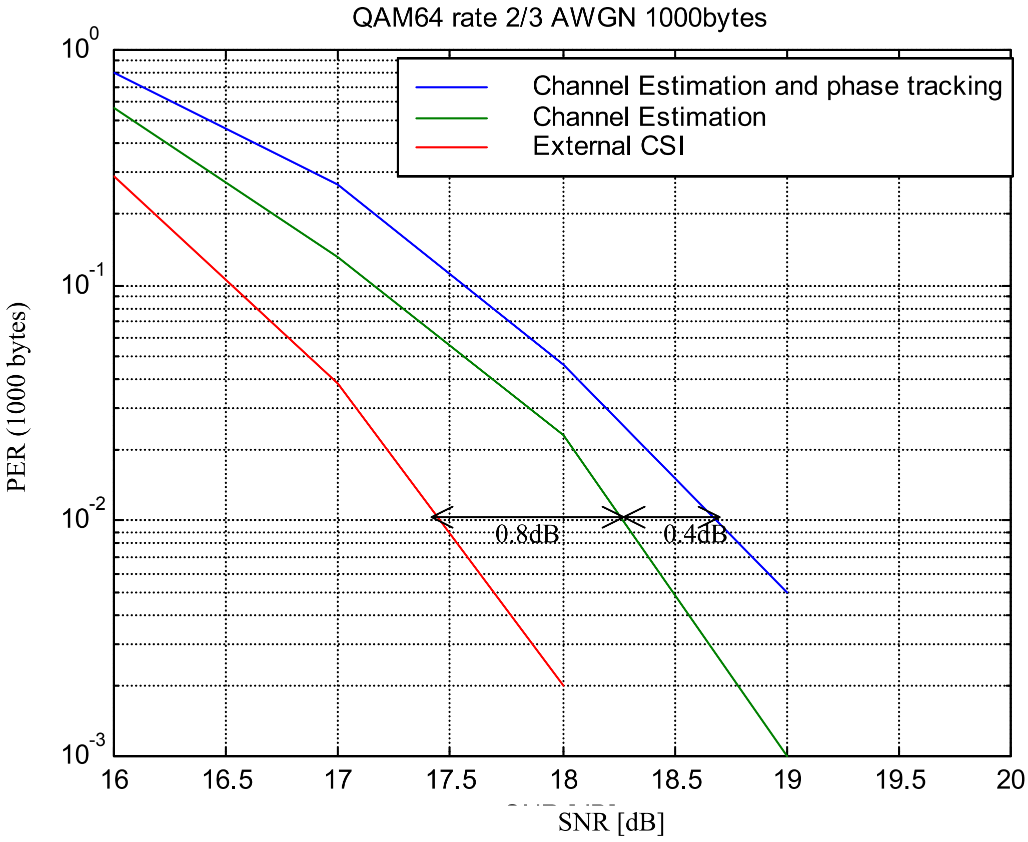

Figure 7 PER vs. SNR Effects of estimation and tracking for QAM64 (1000B packets)

Conclusions

1. The subchanneliaztion scheme is shown to be as robust as the OFDM schemes, in terms of received SNR. The exceptions are:

   A. QAM64 in AWGN conditions at PER below 10^{-2}. The difference is about 0.5 dB for PER $=10^{-3}$.
   B. QAM64 in multipath conditions. The difference at PER$=10^{-2}$ is about 0.5dB and at PER$=10^{-3}$ is about 1dB. For omni directional antennas the difference is about 2dB.

For system level comparison one needs to take into account the subchannelization power gain. This gain is up to 6dB.

2. The channel response can be accurately estimated. The degradation due to imperfect channel estimation is equivalent to that of the OFDM scheme.

3. In the subchannelization scheme defined in 802.16aD6, only two pilots assigned to a sub-channel. For phase tracking decision-aided techniques must be used. This proved to be feasible but not trivial. The phase tracking techniques employed here caused a degradation of 0.4dB.

It is strongly recommended to increase the number of pilots per sub-channel.