Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Spectral Mask and Preliminary Field Trials of a COFDM Modem**
Date Submitted	**2001-03-09**
Source(s)	Jonathan Labs, Yvon Belec, J. Pierre Lamoureux, Stephan Leclerc, Rainer Ullmann, Donovan Young, Xiaode Yu Wavesat Telecom Inc. 4600 rue Cousens Ville St-Laurent, QC H4S 1X3 Canada Voice: (514) 956-6300 ext 325 Fax: (514) 956-8587 mailto:jlabs@wavesat.com
Re:	Call for Improvements and Mergers, IEEE 802.16.3-01/08
Abstract	This paper shows that an OFDM system does satisfy some of the criteria, which was brought into question during Session #11 in Ottawa. To be specific, it shows that an OFDM signal does meet the spectral mask requirements outlined by the FCC regulation under Title 47 of the CFR, section 21.908. This paper also shows qualitatively the performance of a COFDM point-to-point connection under line-of-sight and near or non-line of sight connections.
Purpose	Provide information for comparison of the various PHYs.
Notice	
Release	
Patent Policy and Procedures	

Spectral Mask and Preliminary Field Trials of a COFDM Modem

Jonathan Labs
Yvon Belec
J. Pierre Lamoureux
Stephan Leclerc
Rainer Ullmann
Donovan Young
Xiaode Yu

Wavesat Telecom, Inc.

Abstract

In this contribution, we wish to show that an OFDM system does satisfy some of the criteria, which was brought into question during the session 11 meeting in Ottawa. To be specific, we wish to show that an OFDM signal does meet the spectral mask requirements outlined by the FCC regulation under Title 47 of the CFR, section 21.908. We also want to illustrate the performance of a COFDM point-to-point connection under line-of-sight and near or non-line of sight connections.

All data here is real, taken either in the lab or in the field using the Wavesat Tiger Modem.

The OFDM signal

The PHY that we constructed has the following specifications:

- Total bandwidth = 6 MHz
- 828 carriers in total/ 1024 point FFT
- Carrier spacing = 6.5 kHz
- 64-QAM, 16-QAM and QPSK modulation modes
- RS error control coding (106, 122, 8)
- Three training symbols and a configuration symbol out of 115 symbols in a frame

The modem performance under AWGN is shown by the Bit Error Rate (BER) versus Signal-to-noise ratio (SNR) plots in Figure 1.

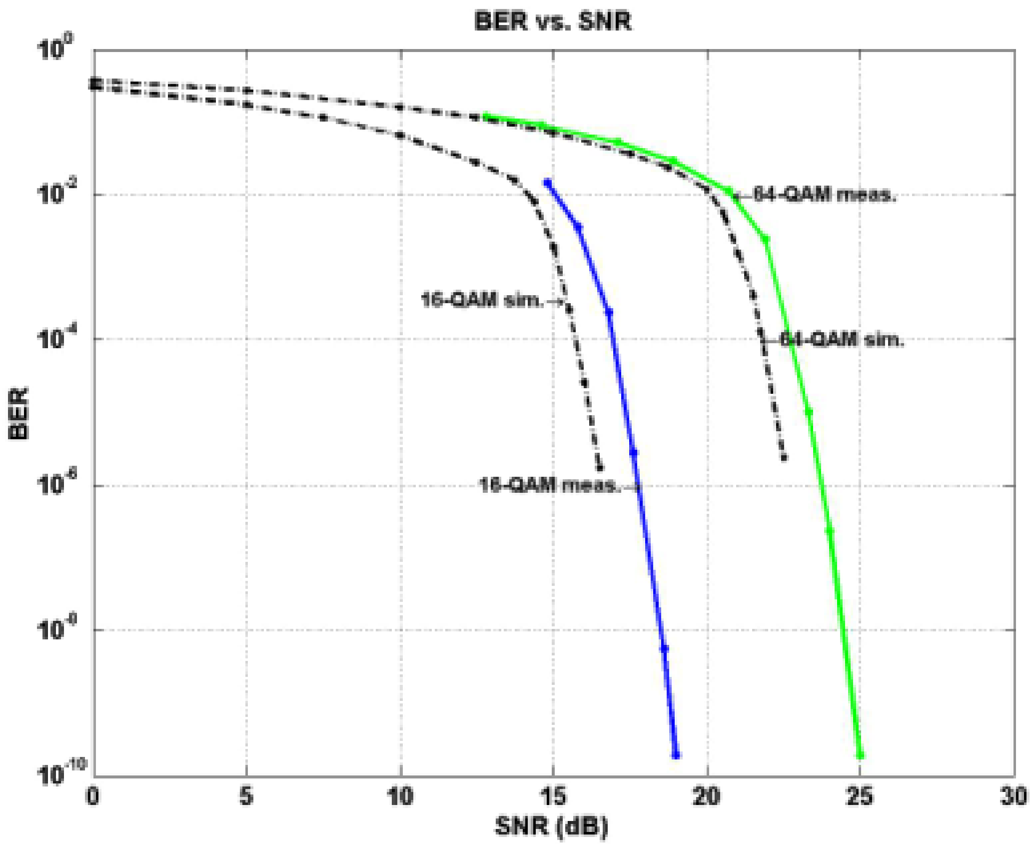

Figure 1. BER vs. SNR for COFDM modem in 64-QAM and 16-QAM mode. Dashed lines show simulation results, while colored lines show lab measurements.

Spectral Mask

Figure 2 shows the spectral regrowth when backed off by 6 dB from the P1dB input compression point of a power amplifier (PA) in a typical transceiver for the MMDS channel B3 (2.533 GHz). The P1dB point for the unit is –9 dBm. A contributing factor to spectral regrowth is the peak-to-average power (PAP) of a signal. For our OFDM signal in 64-QAM mode, the PAP is determined to be 10 dB, with a peak clipping rate of less than 0.5%. Scrambling the input data bits to the modem with a standard pseudo-random sequence, and thereby whitening the signal, achieves this PAP.

One can see that our OFDM signal has no significant problem meeting the FCC mask requirements, with the possible exception at the +-6MHz points. This deviation will be fixed by appropriate filtering.

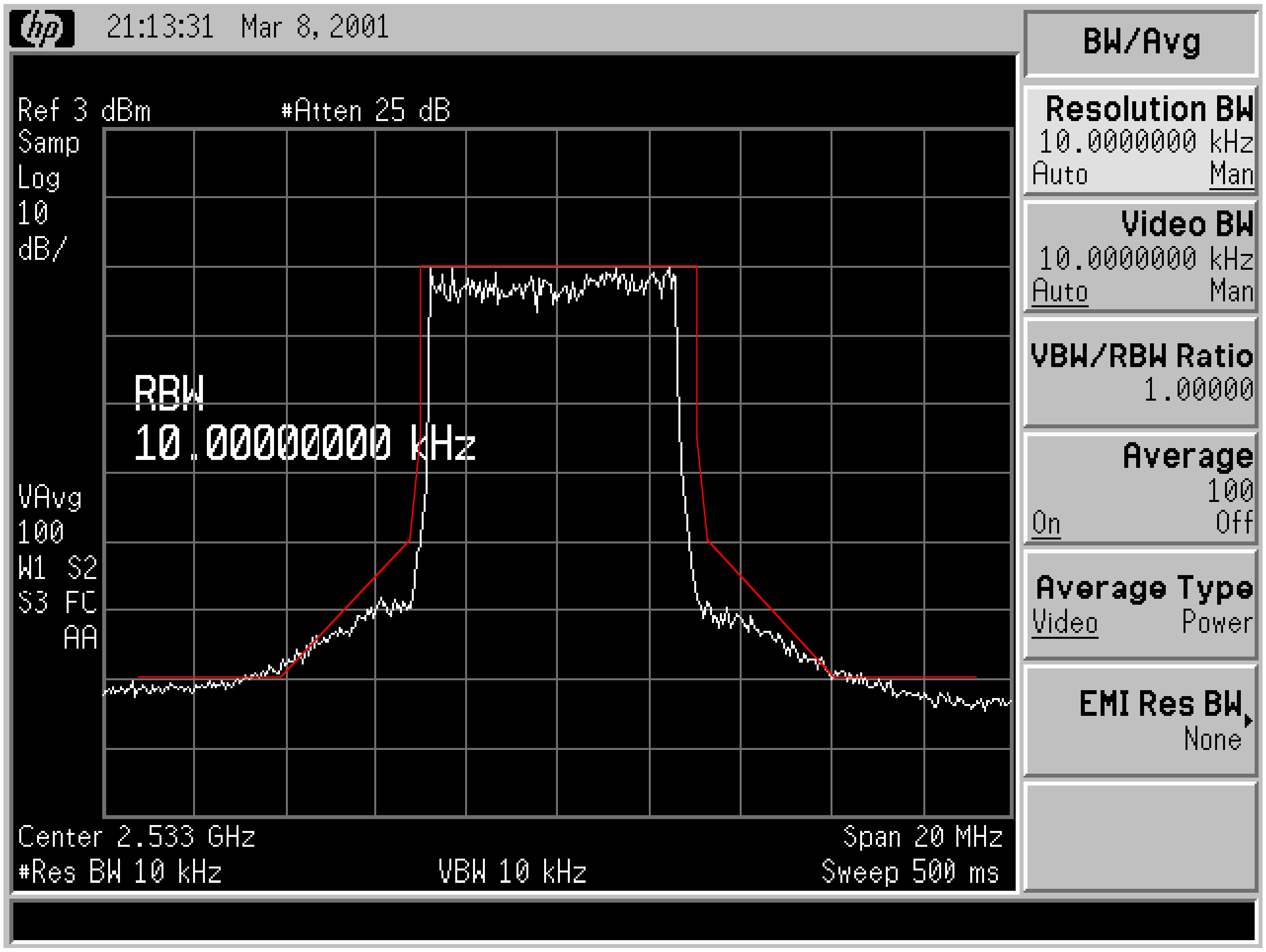

Figure 2. OFDM spectrum at 6 dB back-off from P1dB point of PA.

Field trials

We are undergoing field trials with these modems (currently point-to-point). What we want to present are the type of frequency selective fades we are encountering, and a qualitative result on the system performance.

Our system setup involves two vans, each equipped with 60° sectorized antennas. The connection between the vans is FDD using experimental licenses for the 2.533 and 2.593 channels in the MMDS band. The following figures show the setup. Our licenses from Industry Canada permit us to transmit up 10 mWatt EIRP. The setup is pictured in Figure 3.

Figure 3. Point to point MMDS wireless system

The data transmitted is MPEG over ATM using video-conferencing equipment and then over COFDM with our modem. We show below the spectra resulting under one line-of-sight (LOS) connection, and two non-LOS connections.

Connection #1: Line-of-sight

The two vans were parked approximately 500 meters apart. A link was easily established with the 64-QAM configuration. The spectrum is shown in Figure 4 at the modem's IF receiver.

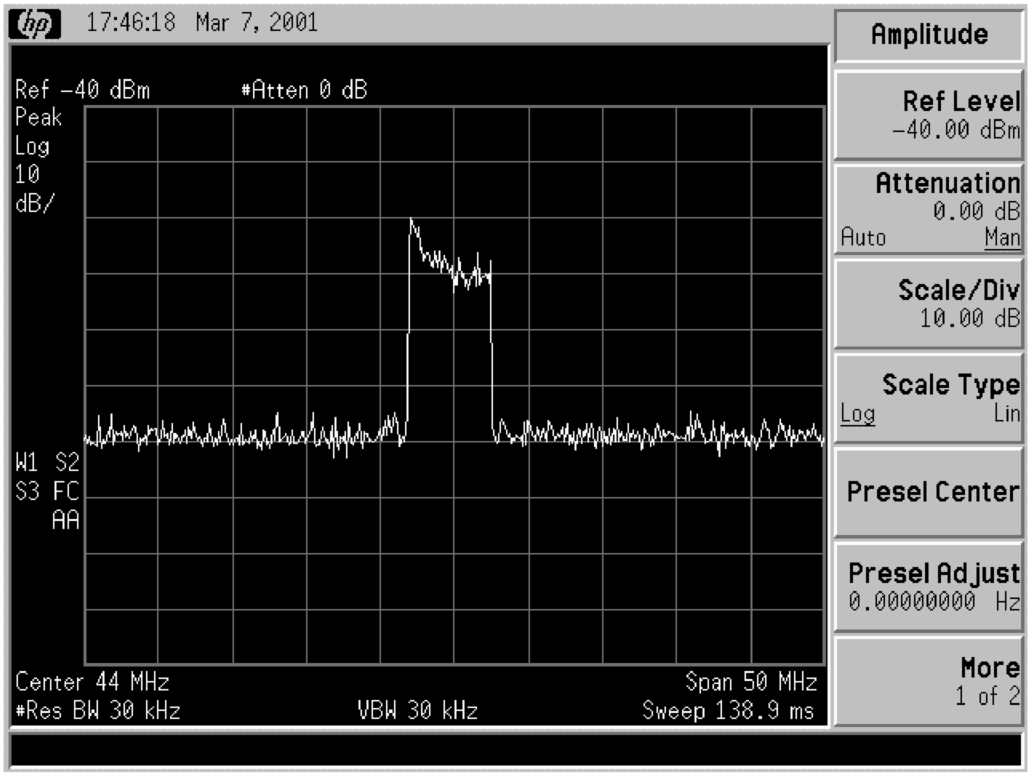

Figure 4. Line-of-sight link in the field

Connection #2: Non-LOS

Two vans were parked such that the receiver was seeing a diffracted and a reflected signal, as sketched in Figure 5.

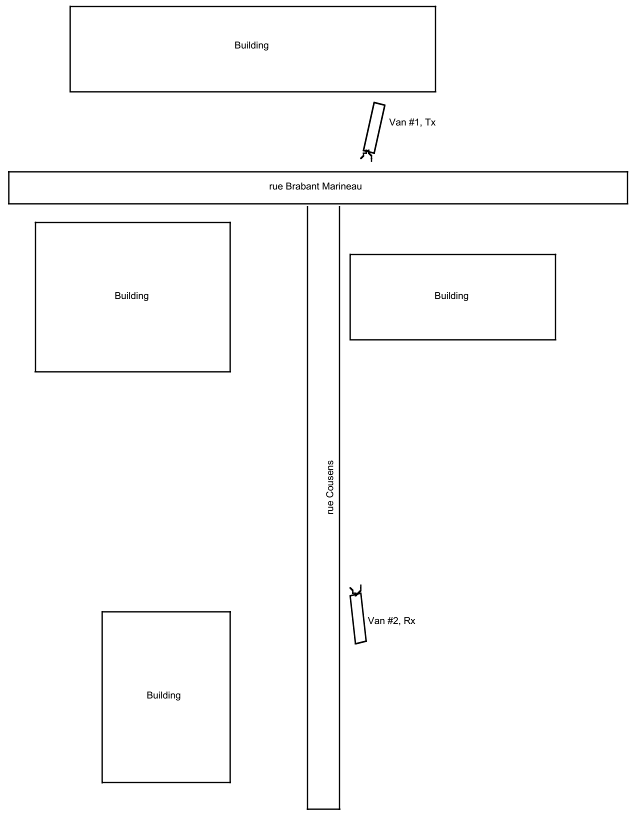

Figure 5. Non-LOS between Tx and Rx with 60° antennas, diffracted and reflected signal.

The channel response for this link is shown in Figure 6. We established a stable link with the modem in QPSK mode.

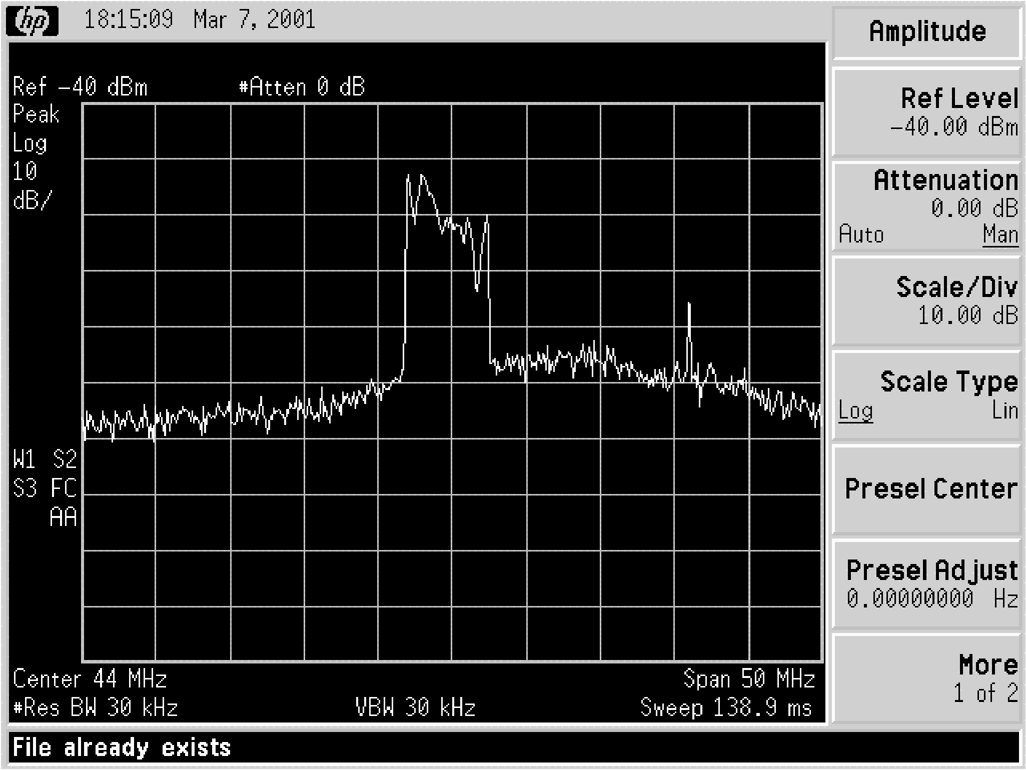

Figure 6. Non-LOS in the field, diffracted and reflected signal.

Connection #3: Non-LOS

In the third configuration, the two vans were parked such that the receiver only saw a reflected signal off a building, as sketched in Figure 7.

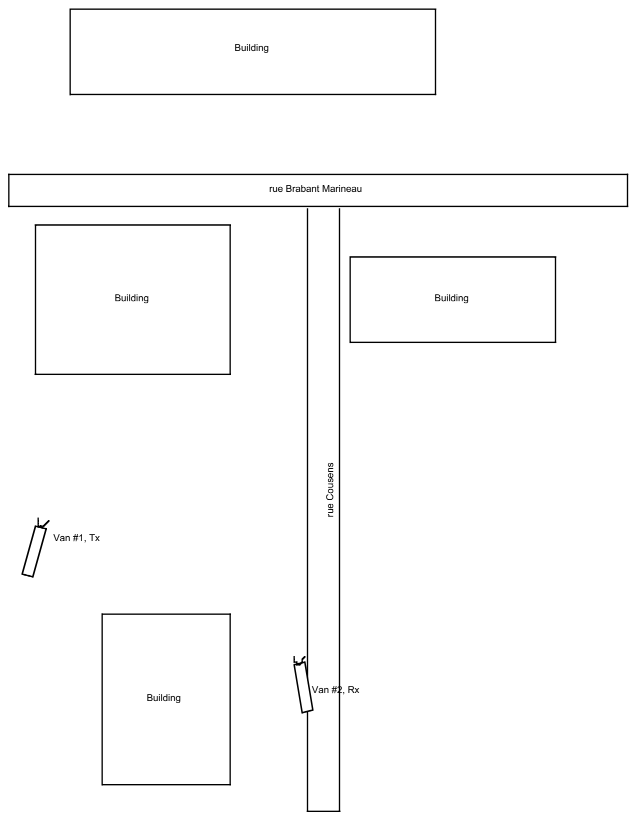

Figure 7. Non-LOS between Tx and Rx with 60° antennas, reflected signal.

The channel response for this link is shown in Figure 8. We again established a stable link with the modem in QPSK mode.

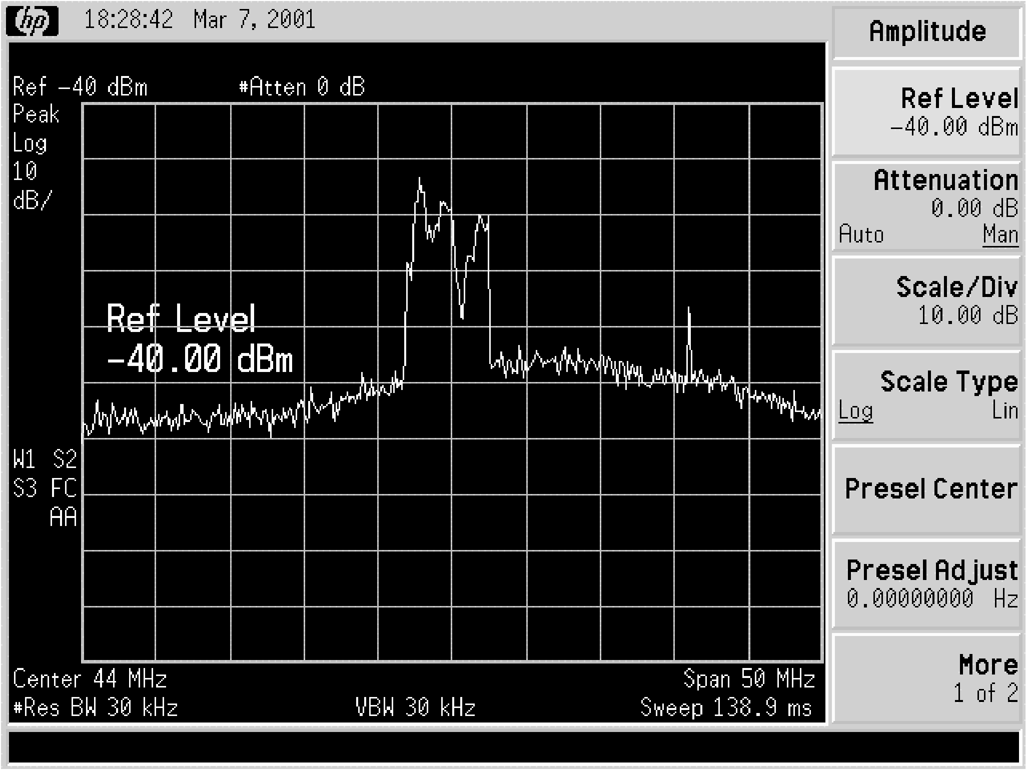

Figure 8. Non-LOS in the field, reflected signal.

Conclusions

We have demonstrated that the spectral mask requirements are not an issue for COFDM for back-off of even 6 dB. We have also shown some of the channel responses, which OFDM can handle.

In the future, we wish to present more quantitative results on the performance of the modem in the lab, for example BER vs. back-off, and in the field for the various non-LOS conditions.