

Chapter 9

Frequency Domain Equalization and Adaptive OFDM vs. Single Carrier Modulation

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ABSTRACT

In the present article an attempt is made to compare multi-carrier and single carrier modulation schemes for wireless communication systems with the utilization of fast Fourier transform (FFT) and its inverse in both cases. With the assumption that in OFDM (orthogonal frequency division multiplexing), the inverse FFT transforms the complex amplitudes of the individual sub-carriers at the transmitter into time domain, the inverse operation is carried out at the receiver. In case of single carrier modulation, the FFT and its inverse are used at the input and output of the frequency domain equalizer in the receiver. Different single carrier and multi-carrier transmission systems are simulated with time-variant transfer functions measured with a wideband channel sounder. In case of OFDM, the individual sub-carriers are modulated with fixed and adaptive signal alphabets. Furthermore, a frequency-independent as well as the optimum power distribution are used. Single carrier modulation uses a single carrier, instead of the hundreds or thousands typically used in OFDM, so the peak-to-average transmitted power ratio for single carrier modulated signals is smaller. This in turn means that a SC system requires a smaller linear range to support a given average power. This enables the use of cheaper power amplifier as compared to OFDM system.

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INTRODUCTION

The basic recipe followed in this article is as follows:

1. For investigating the transmission of digital signals we have used wideband frequency-selective radio channels.
It has been observed that the frequency-selective fading caused by multipath time delay spread degrades the performance of digital communication channels by causing inter-symbol interference, thus results in an irreducible BER and imposes an upper limit on the data symbol rate.
2. We have compared the performance of single carrier and multi-carrier modulation schemes for a frequency-selective fading channel considering un-coded modulation scheme.

Our analysis shows that the un-coded OFDM loses all frequency diversity present in the channel which results in a dip in the channel. As a result of this, the information data on the subcarriers, affected by the dip, is erased. Further, this erased information cannot be recovered from the other carriers. Consequently, it results in a poor Bit Error Rate (BER) performance. However, we can recover frequency diversity and improve the BER performance by adding sufficiently strong coding which spreads the information over multiple subcarriers.

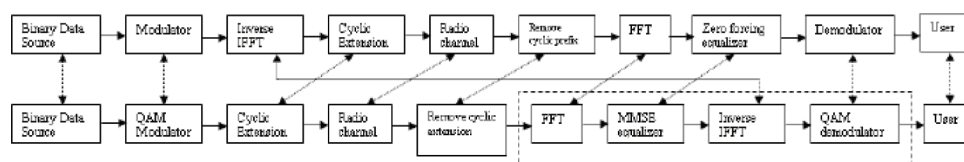
Alternatively, the performance of OFDM can also be improved significantly by using different modulation schemes for the individual sub-carriers. In this scenario, the modulation schemes have to be adapted to the prevailing channel transfer function. Moreover, each modulation scheme provides a trade off between spectral efficiency and the bit error rate. The spectral efficiency can be maximized by choosing the highest modulation scheme that will give an acceptable (BER). In a multipath radio channel, frequency selective fading can result in large variation in the received power of each carrier.

The article is organized as follows: In section II the fixed and adaptive OFDM transmitters are described. A brief description of a single carrier system with frequency domain equalization is given in section III. Section IV deals with the simulations results. Finally, the main conclusions are drawn in section V.

ADAPTIVE OFDM TRANSMISSION

Figure 1 shows the block diagram of the OFDM transmitter used. As can be seen, Binary data is, first, fed to a modulator which generates complex symbols on its output. The modulator either uses a fixed signal alphabet (QAM) or adapts the signal alphabets of the individual OFDM sub-carriers. Both, signal alphabets and power distribution can be optimized corresponding to the channel transfer function. Because of the slow variation of transfer function with time (as shown by the

Figure 1. Block diagram of a) an OFDM and b) a single carrier transmission system with frequency domain equalization



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