2 OFDM SPREAD SPECTRUM COMMUNICATIONS

2.1 INTRODUCTION

Orthogonal frequency division-multiplexing (OFDM) [1, 2] has received considerable attention as a method to efficiently utilize channels with non-flat frequency responses and/or non-white noise. In its most common form, a high rate data stream is divided up among the many carriers in the system in a manner which optimizes the capacity of the overall channel. OFDM can also be used as a spread spectrum modulation (OFDM-SS) [3, 4, 5] wherein spectral spreading is accomplished by putting the same data on all the carriers, producing a spreading factor equal to the number of carriers. At the receiver, the energy from all the carriers is coherently combined to produce the decision variable. Multiple users can be supported in the same channel through code division-multiple access (CDMA) [6]. In this case each user has a unique signature sequence which determines the set of carrier phases. To receive a particular signal, the receiver needs to know the signature sequence for that user in order to align the carrier phases for the coherent combining operation. Figure 2.1 is a block diagram of an OFDM-SS transmitter/receiver pair. As shown in the figure, carrier generation is usually performed efficiently using an inverse fast Fourier transform (FFT) while demodulation is performed using a forward FFT.

Spread Spectrum OFDM has many of the same properties as direct sequence spread spectrum (DS-SS). In essence the primary difference between the two
systems is that DS-SS uses a binary spreading code, consisting of a sequence of 1's and -1's, while the OFDM-SS system uses a spreading waveform, consisting of a series of samples which have non-discrete amplitude values. Indeed, an OFDM-SS modulator can be constructed by storing the spreading waveform and using it to modulate the data in a manner similar to that used with a spreading sequence in DS-SS. The spreading waveform is clearly broadband like the DS-SS spreading sequence and, likewise, has an impulse-like autocorrelation function. Consequently, the OFDM signal is also tolerant of multipath and interference.

At the receiver, the energy from all the carriers is coherently combined to produce the decision variable. A benefit of this type of system arises can be felt the presence of partial-band interference since jammed carriers can be omitted from the coherent combining operation. This technique is similar to transform domain excision which has been studied extensively [7, 8, 9, 10] for use in direct sequence spread spectrum receivers. In these systems, a received signal with partial-band jamming is processed by a transform, most often a short-time Fourier transform or FFT, and portions of the transform which are primarily jammer are “excised”, i.e. set to zero. The effect is to remove most of the jammer energy and only a small amount of desired signal energy, producing improved receiver performance. The excision is performed on a carrier-by-carrier basis, where jammed carriers are omitted from the decision process. Likewise, a frequency domain equalizer can be implemented to jointly combine multiple transmitted paths and suppress interference.