SENSITIVITY OF OFDM/CDMA TO CARRIER PHASE JITTER

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ABSTRACT

In this paper, we investigate the influence of carrier phase jitter on the performance of an OFDM/CDMA system. This carrier phase jitter reduces the performance of the system, defined as the signal-to-noise ratio at the input of the decision device. When all users have the same power level and phase jitter spectrum, it is shown that for the highest load, the degradation only depends on the jitter variance but not on the specific shape of the jitter spectrum.

INTRODUCTION

Orthogonal frequency-division multiplexing code-division multiple-access (OFDM/CDMA) has recently received a considerable attention owing to its possibility to achieve a high capacity per unit bandwidth, which provides us an excellent candidate for high data rate applications [1]-[6].

OFDM/CDMA consists of a combination of two well known and studied modulation techniques. In CDMA, the different users are modulated by codes. All users can transmit at the same time and, as each user makes use of the entire frequency band, a high capacity of the channel is reached. A drawback of CDMA is that the performance rapidly decreases when the number of users increases. Orthogonal frequency-division multiplexing (OFDM) multiplexes the incoming streams on orthogonal carriers. These carriers are spectrally overlapping, in contrast to FDMA which uses non-overlapping channels. Moreover, OFDM is less complex to realize, as it can be implemented using a fast Fourier transform algorithm (FFT).

It is known that multi-carrier systems are more sensitive to carrier phase jitter than single carrier systems [7]. This carrier phase jitter is generated by the phase locked loop (PLL) which converts the received IF signal to the base-band signal. In the OFDM/CDMA system, the carrier phase jitter occurring in the PLL systems gives rise to the multi-user interference (MUI).

In this paper, we derived the degradation of the OFDM/CDMA system caused by carrier phase jitter. An expression for the degradation is presented in terms of the phase jitter spectra and the power levels.

SYSTEM DESCRIPTION

The conceptual block diagram of the OFDM/CDMA transceiver is shown in Fig. 1. A data symbol $a_{n,m}$ with unit energy and at symbol rate $1/T$, transmitted by the $n^{th}$ user during the $m^{th}$ symbol interval, is multiplied with a CDMA chip sequence $\{c_{n,\ell}\}$, $\ell=0,\ldots,N-1$, $N$ denoting the number of chips. Sequences belonging to different users are assumed to be orthogonal. The resulting samples, at a rate $N/T$, are modulated on $N$ equidistant orthogonal carriers using an inverse discrete Fourier transform. The resulting time domain samples are fed to $p(t)$, a unit energy square root Nyquist filter with respect to the interval $T/N$. The complex envelope $s(t)$ of the transmitted signal is disturbed by additive noise and carrier phase jitter. This carrier phase jitter is the phase error between the carrier used for up-converting the baseband OFDM/CDMA signal at the transmitter and the phase-locked carrier used for down-converting at the receiver. All OFDM carriers exhibit an identical carrier phase jitter as they are up-converted by the same oscillator. The phase error $\phi_n(t)$ of user $n$ is modeled as a stationary zero mean process having a bandwidth much smaller than $N/T$. The additive noise $n(t)$ has a power spectrum $S_n(f)$. The complex envelope of the received signal $r(t)$ is given by :

$$r(t) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} \frac{\sqrt{E_{s,n}}}{N} a_{n,m} \sum_{k,\ell=0}^{N-1} c_{n,\ell} e^{j2\pi \frac{k\ell}{N}} p\left(t - (k + mN)\frac{T}{N}\right) e^{j\phi_n(t)} + n(t) \quad (1)$$

The receiver consists of a filter $p^*(t)$ matched to the transmit pulse whose output is sampled at the chip rate at the instants $\{kT/N\}$. In order to detect the symbol $a_{n,m}$, the matched filter output samples are fed to the discrete Fourier transform and the