The Effect of Carrier Phase Errors on Downlink MC-CDMA and OCDMA

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Background

In downlink communication, where the signals of the different users are synchronised by the base station, orthogonal CDMA (OCDMA) can be used. Recently, CDMA has been studied in combination with OFDM in the context of high data rate communication over dispersive channels. One of these combinations is the so-called multicarrier CDMA (MC-CDMA) system, which has been proposed for downlink communication in mobile radio.

MC-CDMA and OCDMA

By using orthogonal sequences of length N in both MC-CDMA and OCDMA, up to N users can be accommodated, while multi-user interference (MUI) is avoided. However, carrier phase errors between the carrier oscillators at the transmitter and the receiver affect the orthogonality of both MC-CDMA [1] and OCDMA, which leads to the introduction of MUI. In this contribution, we compare the performances of MC-CDMA and OCDMA in the presence of carrier phase errors, by including the phase errors in an equivalent time-varying impulse response. We restrict our attention to the case of an ideal channel, so we can clearly isolate the effect of the phase errors.

Let us first consider the case of a constant phase offset ϕ. It can be verified that a constant phase offset rotates the useful component of both systems over an angle ϕ, while no MUI is introduced. A constant phase offset therefore can be compensated without loss of performance.

A carrier frequency offset ΔF gives rise to an attenuation of the useful component and a non-zero MUI, for both MC-CDMA and OCDMA. The degradation is shown in figure 1 for N active users. It follows that both systems are very sensitive to this carrier frequency offset for an increasing sequence length N, and both systems show essentially the same degradations.

To get rid of the frequency offset, a phase locked oscillator can be used for RF to baseband conversion. The resulting phase jitter can be modelled as a zero-mean stationary process with a jitter spectrum $S_\phi(f)$ and variance σ_ϕ^2. The useful component consists of an average component and a zero-mean fluctuation about the average, caused by the phase jitter. The randomly fluctuating phase jitter also introduces MUI. It can be verified that for N active users, the degradations of MC-CDMA and OCDMA are independent of the spectral contents of the jitter and the sequence length N. The degradation, which is essentially the same for both systems, is shown in figure 2.

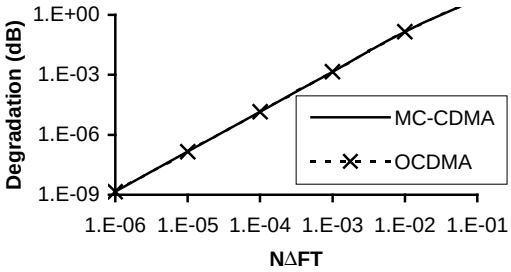

Figure 1 : Carrier frequency offset

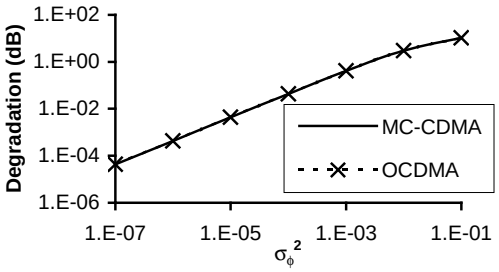

Figure 2 : Carrier phase jitter

Reference

[1] H. Steendam and M. Moeneclaey, "Sensitivity of OFDM and MC-CDMA to Carrier Phase Errors", Proc. SCVT'98, Oct'98, Brussels