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OFDM/ IOTA vs. MC/CDMA- IOTA using a New Channel Estimation Method

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Abstract

Classical OFDM modulation using guard interval is well known for its robustness to multi-path time varying propagation channels. OFDM/IOTA modulation is an alternative to it, which has the advantage not to require the use of a guard interval, this leads to a gain in spectral efficiency. In order to reduce the intrinsic ISI caused by the use of the IOTA filter, we adapt a new method to perform channel estimation efficiently. In this paper, we also suggest MC/CDMA-IOTA system for the purpose of comparison with OFDM/IOTA system.

1. Introduction

Classical OFDM modulation uses a guard interval (or cyclic prefix) to efficiently combat the fading effect, at the price of a loss of spectral efficiency. To remove this guard interval, the prototype function modulating each sub-carrier must be very well located both in the time and in the frequency domain, to limit the inter-symbol and inter-carrier interference. This function must also guarantee orthogonality between sub-carriers. Functions having this double characteristic exist, but only guarantee orthogonality on real values. Among these functions, the localization is optimal with IOTA (Isotropic Orthogonal Transform Algorithm) function.

In the paper, OFDM/IOTA and MC/CDMA-IOTA systems is designed and proposed, then we give the method of IOTA filter designing, and finally , the BER results of the 2 systems both under both AWGN and Rayleigh fading channels are shown by computer simulation.

2. OFDM/IOTA System

2.1 OFDM/OQPSK-IOTA System

In OFDM/OQPSK system, the complex QPSK data stream (c_{mn}) must be separated into its two real components: real part (a_{mn}) and imaginary part (b_{mn}) (see Fig. 1), the imaginary part being modulated with a half-symbol-duration ($T_u/2$) shifted version of the modulation filter [1], [2]. The classical OFDM signal (without cyclic prefix) can be written as

$$s(t)=\sum_{n}\sum_{m=0}^{N_u-1}c_{mn}e^{(2i\pi m\Delta f t)}g(t-nT_u) \qquad (1)$$

So, the corresponding OFDM/OQPSK modulated signal can be written as:

$$s(t)=\sum_{n}\sum_{m=0}^{N_u-1}d_{m,n}i^{m+n}e^{2i\pi m\Delta f t}\Im(t-n\tau_0) \qquad (2)$$

where $d_{m,n}$ = $a_{m,n}$ or $b_{m,n}$. Here $d_{m,n}$ denotes the real information value(Offset QPSK) sent on the m^{th} sub-carrier at the n^{th} symbol, N_u is the number of sub-carriers, υ_0 is the inter-carrier space, τ_0 is the OFDM/OQPSK symbol duration, $\tau_0=T_u/2$, and $\Im$ is the IOTA function. Orthogonality is guaranteed if

$$\mathrm{Re}\left(\int_R \Im_{m,n}(t)\cdot\Im^*_{m',n'}(t)dt\right)=\delta_{m,m'}\delta_{n,n'} \qquad (3)$$

where $\Im_{m,n}(t)=i^{m+n}e^{2i\pi \Delta f t}\Im(t-n\tau_0)$.

It is important to notice that the density of the time-frequency frame related to OFDM/OQPSK equals 2, i.e. $\upsilon_0\tau_0=1/2$. Seen from Fig. 1, for a given inter-carrier spacing υ_0, on each sub-carrier, OFDM/OQPSK carries one real value each while OFDM/QPSK without guard interval carries one complex value each $2*\tau_0$ [2].

Fig.2 illustrates the OFDM/IOTA system transmission /reception chain. The demodulated data is obtained by taking the real part of the projection of the received signal on the corresponding matched poly-phase IOTA filter.

2.2 IOTA Filter Design

The IOTA filter is generated by applying the Isotropic Orthogonal Transform Algorithm to the Gaussian function. The idea is to orthogonalize the Gaussian function, which is optimally localized in the time-frequency space, but is

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