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Implementation and Comparative Analysis of Wireless Techniques in 4G and 5G Communication Systems

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Abstract- *This paper introduces the analysis of new generation techniques which are TDCS (Transform Domain Communication System) and MC-CDMA (Multi-Carrier Code Division Multiple Access). We propose the use of MC-CDMA with Hadamard Walsh spreading codes. The MC-CDMA method, applied to mobile wireless communication systems, offers enhanced performance and flexibility. On the other hand, Transform Domain Communication System (TDCS) is a cognitive-radio technology that avoids frequency underutilization by doing spectrum-scavenging. Based on the TDCS multidimensional property, we detail them in terms of spectrum efficiency and Bit Error Rate (BER).*

Index Terms- Orthogonal Frequency Division Multiplexing (OFDM), Direct Sequence Code Division Multiple Access (DS-CDMA)

1. INTRODUCTION

Multipath fading is not a new problem for wireless communication but recent growth in mobile communication system; attracts the designer to seriously think about the problem because it is difficult to avoid such problem under moving conditions. Because the device is continuously moving we can't impose the restrictions on it and it could travel to many points which fall under selective fading. There are many ways to describe the MC-CDMA, but generally it is described as DS-CDMA again modulated by an OFDM carrier, the number of sub-carriers depends upon the length of spreading code used with DS-CDMA

In a basic TDCS implementation, spectral interference and friendly signal presence are estimated using Fourier-based or general spectral estimation techniques. Once frequency bands containing interference or other signals are identified, typically through estimation and threshold detection, those bands are effectively notched (removed) prior to creating the time-domain fundamental modulation waveform (FMW) using the appropriate inverse transform (e.g., inverse discrete Fourier transform, DFT). Data then modulates the FMW to generate the digitally encoded waveforms. Since the FMW is spectrally synthesized to specifically avoid interference regions, transmitted communication symbols do not contain energy at spectral interference locations, and received symbols are largely unaffected.[1]

1.1 Transform Domain Communication Systems

The present TDCS architecture assumes that both the transmitter and receiver are observing the same electromagnetic environment, and thus produce similar spectral estimates and notches (identical estimates in the ideal case). The channel is assumed to be fixed additive white Gaussian noise (AWGN). The identical observed environment assumption is suitable for "localized" short-range data link applications where the transmitter and receiver are in the same jamming or interference environment. There are a number of scenarios where this "local" assumption is valid, such as aircraft flying in tight formation with the interference remotely located outside the formation. However, since spectral estimation is performed independently at geographically separated locations, the estimates are generally not identical. This can impact transmitted symbols such that:

•They contain energy in spectral regions avoided by the receiver (loss of desired signal energy).

• They have no energy in regions retained by the receiver (increase in undesired noise).

The overall result is decreased detection of SNR and increased symbol error rate [2]. One alternate approach to independent spectral estimation is to use a dedicated feedback channel between the transmitter and receiver. This channel could be used to convey the receiver spectral environment and performance of the forward link to the transmitter [3].

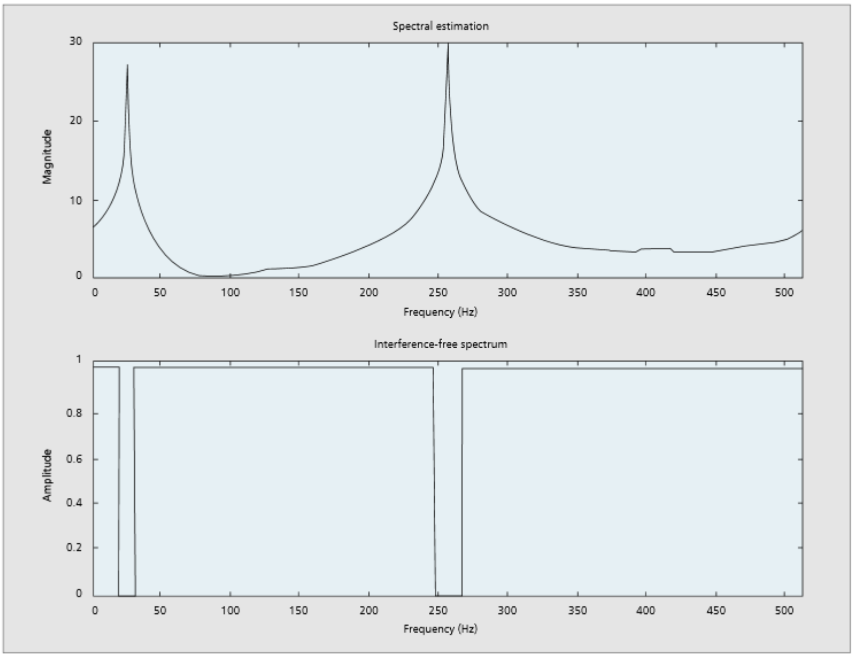

Figure1 Illustration of spectral estimation (top) and corresponding notch (bottom)

1.2 Multi-Carrier Code Division Multiple Access (MC-CDMA)

Multicarrier code division multiple access (MC-CDMA) [4] has emerged as a powerful alternative to conventional direct sequence CDMA (DS-CDMA) [5] in mobile wireless communications. In MC-CDMA, each user's data symbol is transmitted simultaneously over narrow-band sub-carriers, with each subcarrier encoded with a +1or -1 (as determined by an assigned spreading code). Multiple users are assigned unique, orthogonal (or pseudo-orthogonal) codes. That is, while DS-CDMA spreads in the time domain, MC-CDMA applies the same spreading sequences in the frequency domain.

When perfectly orthogonal code sequences are transmitted over slow, flat fading channels with perfect synchronization, the performance of DS-CDMA and MC-CDMA is equivalent, as the orthogonal multi-user interference vanishes completely. However, in reality, wide-band CDMA signals sent over multipath channels experience more severe channel distortions

and the resulting channel dispersion (i.e., frequency selectivity) erodes the orthogonality of CDMA signals. In such cases, it turns out to be far more beneficial to harness the signal energy in the frequency domain (as in MC-CDMA) than in the time domain (as in DS-CDMA) [5]

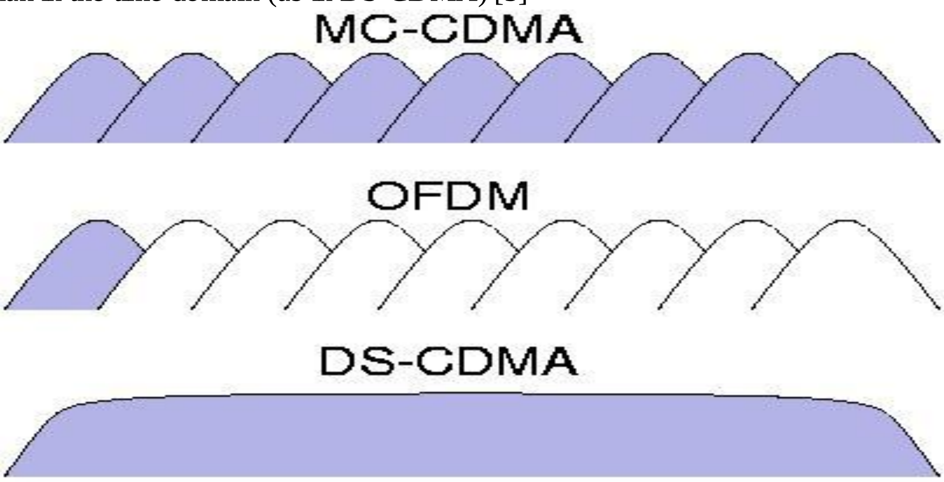

Figure 2 Comparison of MC-CDMA with OFDM & DS-CDMA

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2. Research Gaps

Noise reduction for speech applications is often formulated as a digital filtering problem, where the clean speech estimate is obtained by passing noisy speech through a linear filter/transform. With such formulation, the core issue of noise reduction becomes how to design an optimal filter (based on statistics of the speech and noise signals) that can significantly suppress noise without introducing perceptually noticeable speech distortion. The optimal filters can be designed either in the time or in the transform domain. The advantage of working in transform space is that, if the transform is selected properly, the speech and noise signals may be better separated in that space, thereby enabling better filter estimation and noise reduction performance.

3. Algorithm Implemented:

Functional TDCS implementation involves environmental sampling, spectral estimation, thresholding, notching, phase generation, phase mapping, and inverse transformation to obtain the time-domain FMW(Fundamental Modulation Waveform).

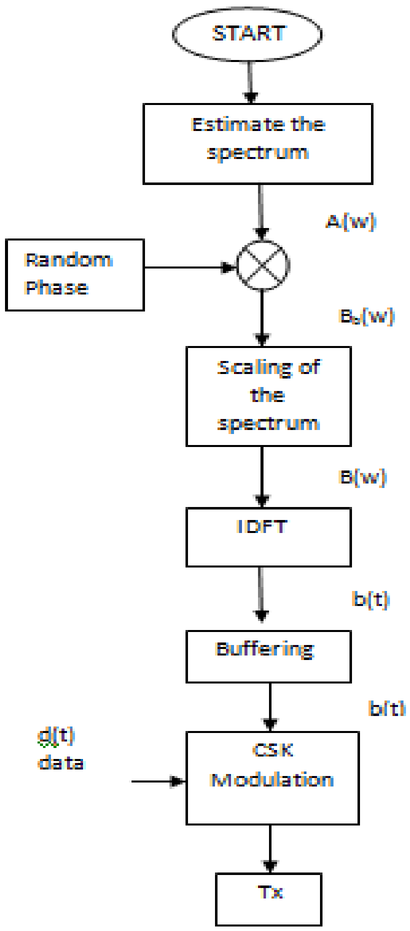

Figure 3 Flowchart for implementation of TDCS

RESULTS

The results for both TDCS and MC-CDMA are shown in graphs. In TDCS modulation makes the symbol occupy only two dimensions as the usual PSK signals. As a consequence, the standard PSK waterfalls curves fit perfectly PSK-TDCS BER results. In MC-CDMA the data were spread using 4-bit Walsh code and modulated using Minimum Shift Keying modulation. In both the graphs the bit error rate is reduced with the increase in the signal to noise ratio.

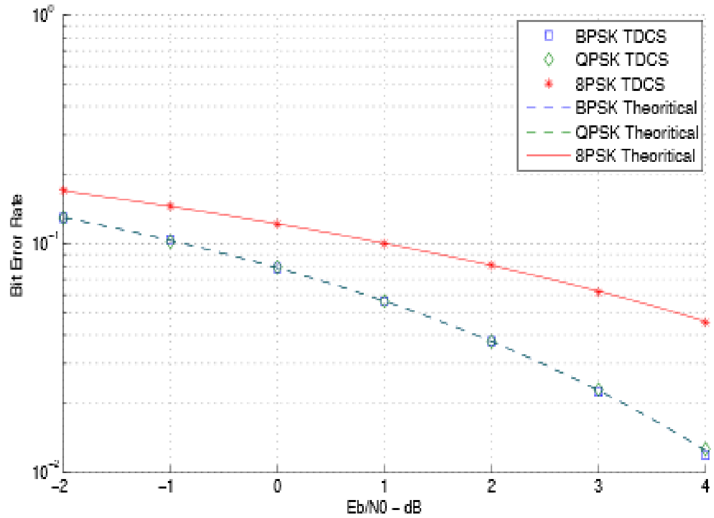

Figure 3 BER performance of TDCS using M_{PSK}-Ary PSK Modulation

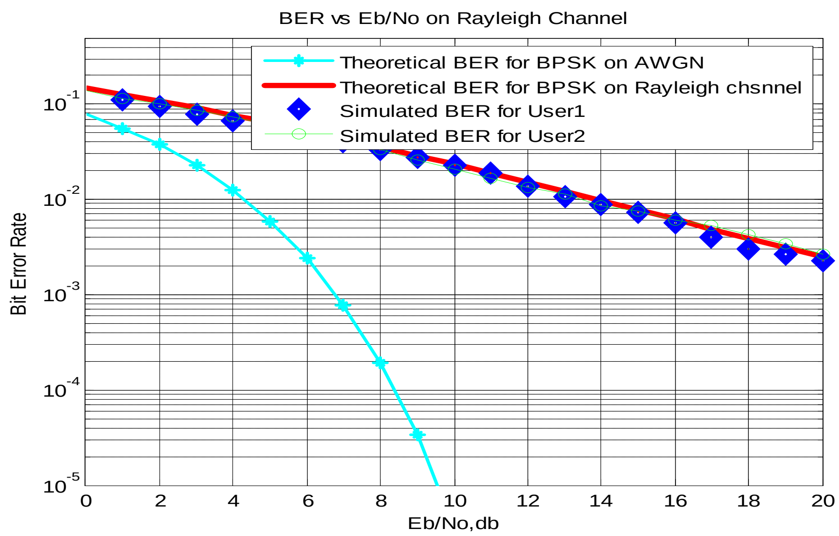

Figure 4 BER vs SNR for MC-CDMA

CONCLUSION

We showed that TDCS is inherently a “power efficient” communication system. By using these modulation techniques, the data rate is increased and the bit error rate is reduced. TDCS was designed to cope with international interference (jammers) at the transmitter and receiver instead of mitigating interference only at the receiver. MC-CDMA gives effective utilization of bandwidth by using proper spreading codes. This article presents a brief overview of TDCS and MC-CDMA.

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