Differentially Coherent Multi-FFT Detection of OFDM Signals in Time-Varying Channels

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Abstract: **Orthogonal frequency division multiplexing (OFDM) is a form of digital modulation used in a wide array of communication systems. In this paper, we propose a class of methods for compensating for the Doppler distortions of the time varying channels for differentially coherent detection of orthogonal frequency-division multiplexing (OFDM) signals. These methods are based on multiple fast Fourier transform (FFT) demodulation, and are implemented as partial (P), shaped (S), fractional (F), and Taylor (T) series expansion FFT demodulation. They replace the conventional FFT demodulation with a few FFTs and a combiner. We investigate the basic principle of OFDM system and through computer simulation, Bit error rate (BER) and peak-to-average power ratio (PAPR) are the parameters will be used as performance of OFDM system for different modulation techniques.**

Keywords: **Differentially coherent detection, Doppler, fading, intercarrier interference (ICI) mitigation, orthogonal frequency division multiplexing (OFDM), Bit error rate (BER).**

1. INTRODUCTION

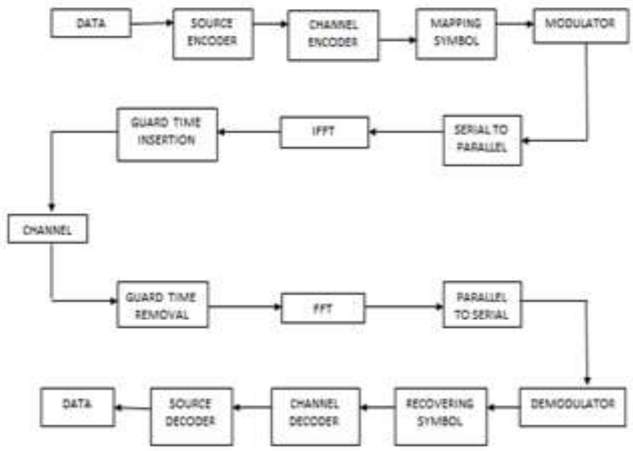
Orthogonal Frequency Division Multiplexing (OFDM) has recently been applied widely in wireless broadband technology due to its high data rate transmission capability with high bandwidth efficiency by using the orthogonality principle.

The OFDM concept is based on spreading the high speed data to be transmitted over a large number of low rate carriers. The carriers are orthogonal to each other. OFDM has some drawback including its higher Peak to Average power reduction (PAPR) and suffer higher sensitivity to Carrier frequency offset (CFO).

Differentially coherent detection eliminates the need for channel estimation, relying instead on the assumption that the channel response changes slowly, either between carriers (differential encoding/detection in frequency) or between blocks (differential encoding/detection in time). If the channel is perfectly known at the receiver, differential detection incurs a penalty (the exact amount depends on the fading); however, channel estimation errors degrade the performance of coherent detection, rendering it equal or even inferior when the channel variation is non-negligible .Moreover, differential detection eliminates the overhead of pilot-assisted channel estimation.

The other variants of FFT are-

1).Partial FFT demodulation (P-FFT)
2) Shaped FFT demodulation (S-FFT).
3) Fractional FFT demodulation (F-FFT)
4) Taylor expansion FFT demodulation (T-FFT).



OFDM BLOCK DIAGRAM

2. MULTIFFT TECHNIQUES-

The goal of multiple-FFT demodulation and combining is to reduce the ICI in the outputs .

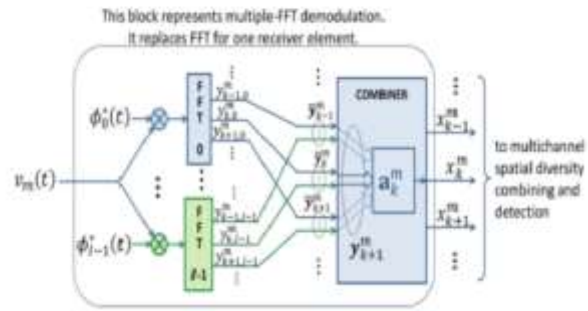


FIGURE 1

Block diagram of multiple-FFT demodulation with P-FFT, S-FFT, F-FFT, or T-FFT. The choice of the functions determines which of the four methods is applied. If ICI equalization is desired, the combiner inputs are extended to include the FFT outputs from the neighboring carriers (dashed arrows inside the combiner block).

Multi-FFT demodulation takes a different approach to address the problem of channel-matched filtering. It is based on the assumption that the channel functions Hk(t) can be projected onto a small set of pre-defined functions Øi(t), such that

$$H_k(t) \sum_{i=0}^{I-1} Ø_i(t)\ H_{k,i} \quad ,k=0 \text{ to } K-1$$

We assume some of the choices for the projection functions are illustrated in Fig.2.

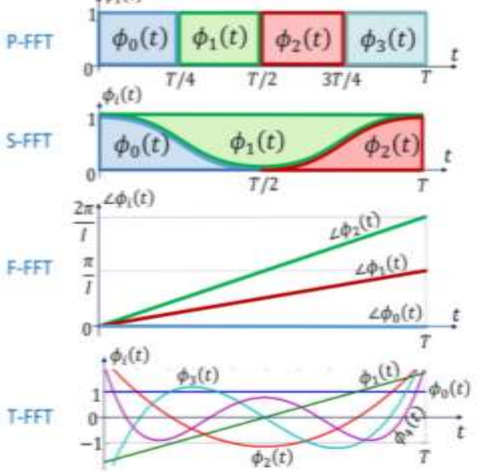


FIGURE 2

- P-FFT uses decomposition onto a set of non-overlapping flat windows in time.
- S-FFT uses smooth windowing.
- F-FFT is based on a decomposition onto complex exponentials.
- T-FFT uses Taylor series polynomials

$$\emptyset_i(t) = \begin{cases} rect\left(\frac{It}{T}\right) - i & PFFT \\ \frac{\left(rect\frac{(I-1)t}{2T} - \frac{i-1}{2}\right)\left(1 + cos\left(\frac{(I-1)\pi t}{T} - i\pi\right)\right)}{2} & SFFT \\ e^{\frac{j2\pi i\Delta f t}{I}} & FFFT \\ C_0^{(i)} + C_1^{(i)}t + \cdots + C_{i-1}^{(i)}\ t^{i-1} & TFFT \end{cases}$$

P-FFT divides the received OFDM block into sections which are times shorter than the original OFDM block. If the sections are sufficiently short, the channel variations are expected to be negligible during each section. The combiner reassembles the sections after giving each section a different weight. P-FFT thus resembles channel-matched filtering where the function is approximated as piecewise constant.

F-FFT provides frequency-domain samples of In OFDM, BER depends upon the modulation technique. As the simulation shows by increasing the PSK order, BER will increase as a trade-off for decreasing run time. As SNR increases, BER will be decreases. And higher order PSK requires a larger SNR to minimize BER. QAM is widely used rather than QPSK because it comprises of amplitude as well as phase, while QPSK only have phase. If the signal in QAM is corrupted it can be corrected either by amplitude or phase. By using QAM error will be reduced or SNR will improve compared to QPSK the received signal at fractions of the carrier spacing to make it easier for the receiver to compensate for the large Doppler shifts .Sampling the spectrum at half the carrier spacing makes compensation of any Doppler shift in the range feasible at very low complexity (a three-tap combiner suffices).

T-FFT is based on polynomial expansion of the time-varying channel coefficients. The idea of estimating the channel coefficients in time and/or frequency domain by polynomials and used for equalization where a 2-D polynomial expansion (in time and frequency) is employed to increase the accuracy of channel estimation and ICI equalization.

S-FFT which provides a smooth decomposition of the channel, preserving the continuity of the approximations. This change, however ,comes at the cost of correlation between FFT outputs as these condition have some overlap.

3.LITERATURE REVIEW

In this paper, we considered an OFDM system in a fast varying mobile scenario with severe inter-carrier interference. An adaptive algorithm for recursively determining the combiner weights is pro-posed and the performance improvement obtained by using partial FFTs is demonstrated for underwater acoustic communication [2].

In this paper, based on the analysis of the symbol energy distribution and the ICI generation mechanism, we propose a low-complexity partial minimum mean-squared error (MMSE) with successive detection (PMMSESD) scheme in frequency domain to mitigate ICI caused by time-varying channels [3].In this paper, a full review of block-type and comb-type pilot based channel estimation is given. Channel estimation based on block-type pilot arrangement with or without decision feedback equalizer is described [19].

Multi-FFT demodulation can be applied with either coherent or differentially coherent detection. Differentially coherent detection may have advantages on time-varying channels where coherent detection suffers from channel estimation errors. Differential encoding is best performed in the frequency domain, i.e. across the OFDM carriers. [6].This contribution introduces a new transmission scheme for multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems.

This scheme is based on channel coding using estimated channel parameters from a transmitted pilot data at the receiver end. In this paper, several important aspects are described as well as mathematical analysis is provided, including the distribution of the PAPR used in OFDM systems

Three typical signal scrambling and distortion techniques, SLM, PTS and Companding are investigated to reduce PAPR, all of which have the potential to provide substantial reduction in PAPR. Proposed Companding method performs better than PTS method and SLM method in reducing PAPR.[16].

We considered differentially coherent detection of acoustic OFDM signals and proposed four demodulation methods for channels with severe

Doppler distortion where random, time- varying frequency shifts can be comparable with the carrier spacing. Instead of the conventional, single-FFT demodulation, these methods use multiple-FFT demodulators where the input to each FFT is a specific transformation of the received signal. The type of transformation—windowing in time, frequency- shifting, projection onto series functions—defines the particular method as the partial (P), shaped (S), fractional (F), or Taylor series (T) FFT demodulation The performance of the four proposed demodulation methods was compared to that of conventional detection (coherent and differentially coherent) using simulation and experimental data. The proposed methods were also compared to coherent and differentially coherent detection methods which employ linear ICI equalization.[1][4][5]

According to the information regarding all above described techniques to reduce the PAPR in OFDM system all techniques are different in their way and by using each technique PAPR can be reduced to some what level. The efficient PAPR exists for any PAPR reduction technique for which the following statement is true the BER of the information bits increases as the reduced PAPR decreases. [14]

In this paper, we investigated the effects of CFO in OFDM signals. Both mathematical analysis and simulation results showed that CFO violates the orthogonality principle, and hence introduce ICI, decreases the SNR of the signal and increases the bit error rate.[11]

4. CONCLUSION -OFDM techniques are quickly becoming a popular method for advanced communications networks. As a result when we should increase the no. of carriers then bandwidth efficiency should be increases. It should be minimizes the no. of blocks per frame. Carrier spacing should be decreases. Transmission rate should be increases. And BER should be improved. We use different multifft techniques to compare these parameters.

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