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Performance comparison analysis between Multi-FFT detection techniques in OFDM signal using 16-QAM Modulation for compensation of large Doppler shift

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Abstract*-Orthogonal frequency division multiplexing (OFDM) is the multi-carrier modulation techniques which divides the frequency selective fading into large number of narrowband flat fading sub-channel. We propose a class of methods for compensating for the Doppler distortions 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 we present the Evolution of combiner weights corresponding to one receiving element as detection proceeds over carriers and OFDM blocks during one frame with 2^9 carriers for the first receiver element by using 16 QAM modulation techniques.MSE and BER values are calculated for proposed method by using 16- QAM modulation and compared with QPSK modulation.*

Keyword**-OFDM, Doppler Shift, 16-QAM, ICI Mitigation Techniques.**

1. INTRODUCTION

OFDM is the key wireless technology for high data rate transmission in which the available spectrum is divided into several sub-channel and each sub-channel is modulated by a low data rate. It operates large bandwidth up to 20 MHz and high data rate up to 100 Mbps. If the subcarrier signals accomplish the orthogonality condition then this result in overlapping of spectrum and hence spectral efficiency is improved. This technique is known as Orthogonal Frequency Division Multiplexing (OFDM). Data with bit rate R is transmitted into N parallel channels, each one of them with separate frequencies. Over each channel, the total bit rate is spread in equal parts at rate R/N. In each channel the data will be mapped to represent an information symbol and then multiplied by its corresponding frequency. These parallel information symbols are summed to form one OFDM symbol. Thus the duration of each OFDM symbol is Ts=N/R. Orthogonality provides the carriers a suitable cause to be narrowly spaced with overlapping without inter carrier interference.

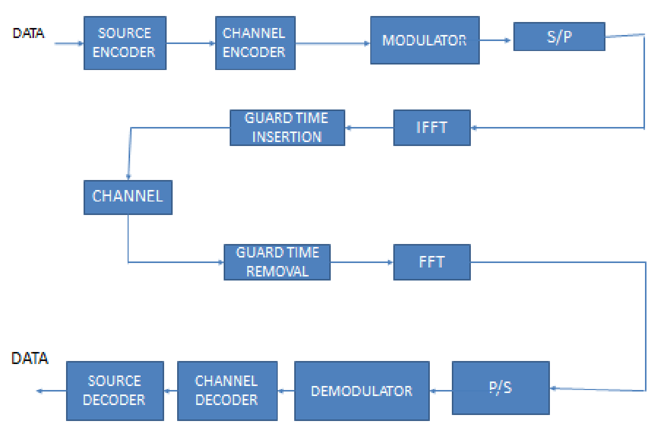

FIG.1.1 OFDM BLOCK DIAGRAM

2. MULTI-FFT DEMODULATION AND COMBINER

- The goal of multiple-FFT demodulation and combining is to reduce the ICI in the outputs.
- Pre-processing based on optimal, multiple resampling of the received signal.
- Multiple FFT demodulators are used to approximate the optimal receiver front-end for arbitrarily time-varying channels.

- Multiple FFT demodulators includes a technique for predicting the Doppler shift from the combiner weights.
- The proposed receiver replaces the conventional, single FFT demodulator with a few (e.g. two) FFTs and combiner whose outputs are combined in a manner that minimizes post detection error.
- The receiver also incorporates spatial diversity combining, an adaptive channel estimator and a phase prediction method to track the channel response across OFDM blocks.

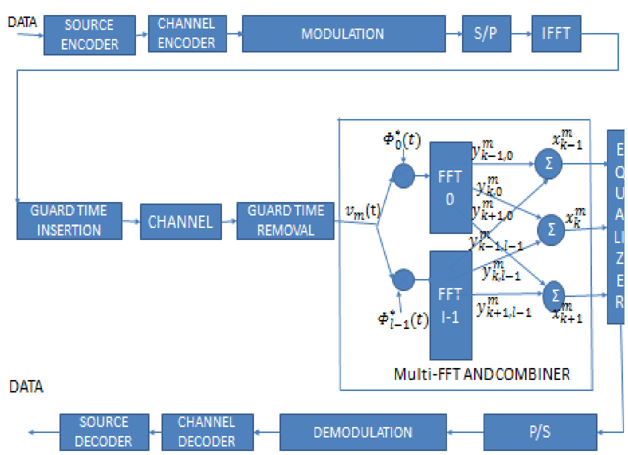

FIG.2.1 PROPOSED OFDM SYSTEM DESIGN

3. PROPOSED METHODOLOGY

The multiple-FFT demodulation techniques draw on the notion that the channel variations may be decomposed based on a set of predefined functions. Given such a decomposition, the received signal is projected onto these functions, and the projections are passed on to FFT demodulation and subsequent combining.

The four ICI mitigation methods :

Partial FFT demodulation (P-FFT)

Shaped FFT demodulation (S-FFT)

Fractional FFT demodulation (F-FFT)

Taylor FFT demodulation (T-FFT).

3.1. PARTIAL FAST FOURIER TRANSFORM (P-FFT)

P-FFT divides the received OFDM block into I sections which are I 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 $H_k^{m*}(t)$ is approximated as piecewise constant.

P-FFT uses decomposition onto a set of non-overlapping flat windows in time.

$$\emptyset_i(t) = rect\frac{It}{T} - i$$

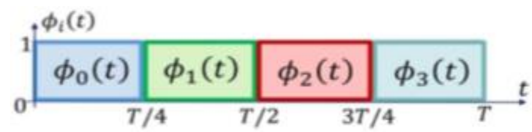

FIG. 3.1 Non overlapping rectangular wave- forms, eachcovering an interval of length (P-FFT)

3.2. SHAPED FAST FOURIER TRANSFORM (S-FFT)

The precision of the approximation $H_k^{m*}(t)$can be improved by smoothing the transitions between the sections. To this end, we introduce S-FFT which provides a smooth decomposition of the channel, preserving the continuity of the approximations to $H_k^{m*}(t)$.

S-FFT uses smooth windowing.

$$\emptyset_i(t) = \left\{ \frac{rect\left(\frac{(I-1)t}{2T}\right)\left(1 + \cos\left(\frac{(I-1)\pi t}{T} - i\pi\right)\right)}{2} \right.$$

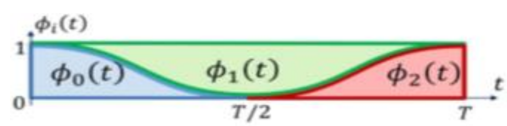

FIG. 3.2 Raised-cosine waveforms (S-FFT)

3.3. FRACTIONAL FFT DEMODULATION (F-FFT)

The FFFT is a generalization of the ordinary Fourier transform with an order parameter α and is identical to the ordinary Fourier transform when this order α is equal to $\pi/2$. The FFFT belongs to the class of time–frequency representations that have been extensively used by the signal processing community. In all the time–frequency representations, one normally uses a plane with two orthogonal axes corresponding to time and frequency.

F-FFT is based on a decomposition onto complex exponentials.

$$\emptyset_i(t) = e^{\frac{j2\pi i\Delta f t}{I}}$$

FIG.3.3 complex exponentials at multiples of a fraction of the carrier spacing (F-FFT)

3.4.TAYLOR FFT DEMODULATION (T-FFT)

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.

T-FFT uses Taylor series polynomials

$$\Phi_i(t) = C_0^{(i)} + C_1^{(i)} t + \ldots + C_{i-1}^{(i)}\ t^{i-1}$$

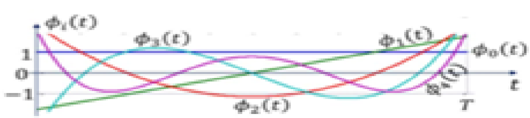

FIG. 3.4. Orthogonal polynomials of degrees 0 to (T-FFT).

4. RESULT AND SIMULATIONS

Evolution of combiner weights corresponding to one receiving element as detection proceeds over carriers and OFDM blocks during one frame with 2^9 carriers for the first receiver element by using 16 QAM modulation techniques.

4.1.PARTIAL FAST FOURIER TRANSFORM

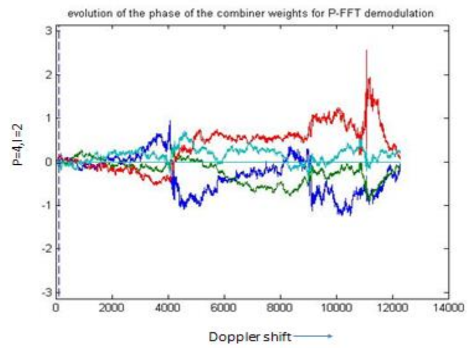

FIG.4.1.The plots show the phase of a_k^1 for P-FFT and estimated Doppler shift

4.1SHAPED FAST FOURIER TRANSFORM

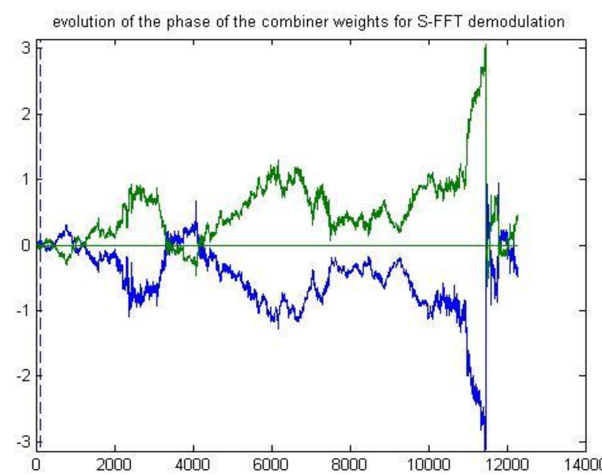

FIG 4.2.The plots show the phase of a_k^1 for S-FFT and estimated Doppler shift

4.3. FRACTIONAL FAST FOURIER TRANSFORM

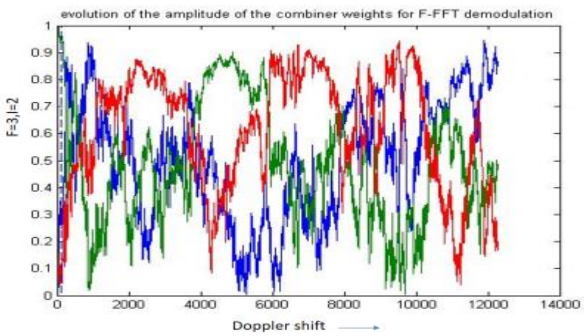

FIG.4.3.The plots show the magnitude of a_k^1 for F-FFT and estimated Doppler shift

4.4. TAYLOR FAST FOURIER TRANSFORM

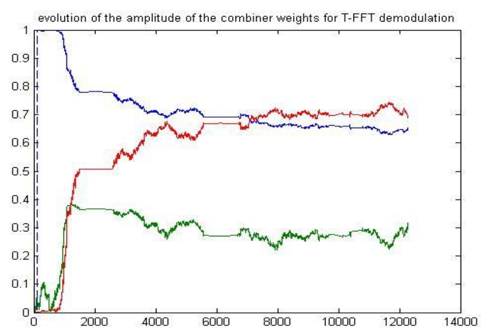

FIG.4.4.The plots show the magnitude of a_k^1 for T-FFT and estimated Doppler shift

4.5. CONVENTIONAL DETECTION WITH 3 EQUALIZER TAPS

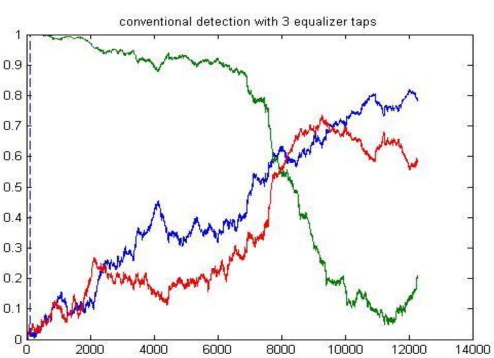

FIG.4.5.The plots show the magnitude of a_k^1 for conventional detection with 3 equalizer taps and estimated Doppler shift

4.6.CONVENTIONAL DETECTION WITH 5 TAP EQUALIZER

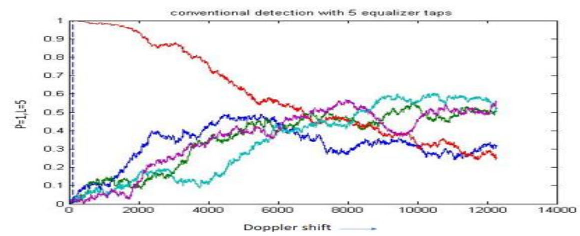

FIG.4.6.The plots show the magnitude of a_k^1 for conventional detection with 5 equalizer taps and estimated Doppler shift

4.7. COMPARATIVE ANALYSIS

The MSE is improved by using 16 QAM modulation techniques as compared to QPSK.

Multi-FFT Techniques	MSE (16 QAM) (Proposed Work)	MSE(QPSK) (Base Paper Work)
P-FFT	-18.18	-9.8
S-FFT	-17.90	-10
F-FFT	-17.67	-10.5
T-FFT	-16.12	-9
Conventional detector with 3 equalizer taps	-17.95	-4.57
Conventional detector with 5 equalizer taps	-17.93	-7.18

The BER (Probability of error) is reduced by using 16 QAM modulation techniques as compared to QPSK.

Multi-FFT Techniques	BER (16 QAM) (Proposed Work)	BER(QPSK) (Base Paper Work)
P-FFT	0.0015	0.0045
S-FFT	0.0015	0.0022
F-FFT	0.0015	0.0035
T-FFT	0.0015	0.0042
Conventional detector with 3 equalizer taps	0.0015	0.0516
Conventional detector with 5 equalizer taps	0.0015	0.0143

5. CONCLUSION

- It is concluded that the multi-fft detection techniques has been applied to find out the MSE and BER performance of system using 16 QAM modulation scheme.
- The MSE and BER value has significantly improved by multi-FFT detection using 16 QAM as compared to QPSK.

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