# DOPPLER PHENOMENON ON OFDM AND MC-CDMA SYSTEMS

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**ABSTRACT**

**The focus of work is Doppler Phenomenon on OFDM and MC-CDMA system. The emphasis is given on channel capacity between OFDM and MC-CDMA versus antenna speeds for different SNR. The proposed working model was Minimum Mean Square Error (MMSE) at receiver is analyzed for transmission with Doppler for MC-CDMA. Our work has been concentrated on Doppler shift but Doppler spread creates more degradation in the performance of the receiver. The Doppler spread effect can be minimized by using Adaptive Equalization techniques.**

## 1 Introduction:

Doppler spread occurs causing dispersion is frequency between Tx and Rx on OFDM. It can also be defined as when its spread is larger than when compared to coherence time channel then the channel is **fast fading channel, if less is slow fading.**.

When the coherence time is large there is hardly any effect on the channel capacity and if less of error of frame time or less capacity falls significantly. Since communication systems use frequency offset and correction as an inherent part of the channel capacity. However, in the absence of carrier tracking in the receiver the system performance and capacity may full. A Doppler shift is fixed frequency offset [1] and is correlated by cyclic prefix. Due to this sub carriers are orthogonal in multipath channel. Performance of MC-CDMA inherits from OFDM with high spectra l efficiency and robustness against multi-path propagation. OFDM type of transmission influences time variations of channel allowing flexibility of channels. In [2-3] the effect of a carrier frequency offset in MC-CDMA Doppler shift, minimum mean square error [MMSE] receiver has been discussed for slowly changing channels. BER of MC-CDMA estimated theoretically [4] with linear receiver. Performances of MC-CDMA have been compared with OFDM.

Emphasis is given on channel capacity between OFDM and MC-CDMA versus antenna speeds for different SNR. The Minimum Mean Square Error at receiver is analyzed for transmission with Doppler for MC-CDMA. Our work has been concentrated on Doppler shift but Doppler Spread creates more degradation in the performance of the receiver. The concept and analysis of OFDM and MC-CDMA with Doppler, OFDM and MC-CDMA channel capacity, simulated results are presented with concluding remarks.

**2 OFDM and MC – CDMA with Doppler**:

OFDM Transmissions FFTs generate and decompose the data signal of multi-carrier form is applicable to OFDM.

$$S(t) = \sum_{n=0}^{N-1} a_n \, exp\,(jw_c t + nw_s t) \qquad \dots (1)$$

Where $W_c$ → Carrier frequency
$W_s$ → Subcarrier spacing
n → Subcarrier number
N → Number of Subcarrier and
$a_n$ → modulation of the n th Subcarrier carrying the user data.

In MC – CDMA, A =BC, where B = [ $b_o$, $b_1$ .. $b_{n-1}$] $^T$ represents a frame of user data refer to as N user signals and C is and N by N code matrix. The C represents the "Spreading code" of user data stream K of that column, and will be denoted as ( CK[0]… CK [N-1]) $^T$. A commonly used speial case which isconsidered here is C = $N^{-1/2}$and Walsh – Hadamard matrix ($WH_N$) of size N by N. In that case, C = $C^{-1}$ = $C^H$, so $CC^H = I_N$ with $I_N$ the N by N unit matrix. In another special case, namely that of C = $I_N$, with $I_N$ the MC – CDMA, vector A of length N carries a 'frame' of user data with A = [ $a_0$ , $a_1$ … $a_{N-1}$]$^T$ where the elements an user symbols. For simplicity of investigation, normalized modulation as $Eb_ib_j = f_{ij}$ or $EBB^H = I_N$. then E $(AA^H) = EC\,(BB^H)\,C^H = CC^H = I^H$.

Frames are created by a serial to parallel conversion of an incoming stream of data, applying the code spreading, an IFFT and a parallel – to – serial conversion with prefix inserted shown in fig 1 (a). Utilizing Guard intervals interference is avoided in transmission of single frame $W_sT_s = 2\,\pi$. The wide sense stationary uncorrelated scattering multipath channel model as a collection of $I_w$ reflected waves. Each wave has its particular Doppler frequency offset $W_i$, path delay $T_i$ and amplitude Di, each of which is assumed to be constant. The Doppler offset wi = 2 πfiw; with total spread of 4πf , with f Δ = Vfc the maximum Doppler shift.

The received signal r(t) is represented by consisting of number of reflected waves with white Gaussian noise n(t).

$$r(t) = \sum_{N=0}^{N-1} \sum_{i=0}^{ln-1} a_n \, D_i \exp\{j(w_c + nw_s + w_i)(t - T_i)\} + n(t) \qquad \dots (2)$$

**Linear Receiver Architecture for MC-CDMA:**

Finding signal sub-carrier m is obtained with subcarrier frequency in interval Ts with exp $\{-jw_it - jmw_it + \phi m\}$ .

$$Ym = \sum_{n=0}^{N-1} \sum_{t=0}^{tu-1} a_n \, D_i \int_0^{Ts} \exp\{j(n-m)w_s t + w_i t - j(w_c + nw_s + w_i)T_j\}\, dt + n_m \quad - \dots\dots (3)$$

$n_m$ noise sampled subcarrier,
Subcarrier offset denoted as

$\Delta$ = n –m, so

$Y_m = \sum_{n=0}^{N-1} \sum_{i=0}^{t_m-1} \frac{ja_n D_i}{w_s+w_i}$ $[_\Delta$ exp{ j($\Delta$ $w_s$+$w_i$) $T_s$} -1] exp { -j($w_c$+n$w_s$+$w_i$) $T_i$} +$n_m$ ...(4)

By rewriting the above expression as $Y_m = \Sigma_n\, an\beta n,$ n$T_s$ where $\beta_{m.n}$ isleakage o signal transmitted at subcarrier. usingsinc (x) = $\frac{\text{Sin}(\pi x)}{\pi x}$ and $W_sT_s = 2\pi$, them

$\beta_{m.n}\sum_{i=0}^{Lw-1}\frac{D_i}{2}$ Sinc (n-m+$\frac{W_i}{W_t}$ ) exp {-j($W_c$+$W_i$+n$w_s$) $T_i$ - $\frac{1}{2}$j$W_iT_s$ +j$\pi$ (n-m)} ... (5)

This result can be interpreted as sampling in frequency domain. The $I_w$ multipath channel contributions appear weighted according to their individual Doppler offset Wi. It confirms that due to the Doppler shifts, the detected signal $Y_m$ contains contributions from all n subcarrier signals, not only from m=n. All $\beta$ mn's with m ≠ n lead to ICI, with amplitudes weighed by sinc$(n - m + \frac{W_i}{W_s})$

**3 OFDM MC-CDMA CHANNEL CAPACITY:**

A comparative study of systems based on capacity pe subcarrier is realize in present study Maximum efficiency of link arrives with identification of symbols and address of MC-CDMA. A loss of performance occurs relative to ideally coded OFDM in a system that extracts N **MC – CDMAsymbols** and processes these as if they were transmits method over an **AWGN, linear time invariant, and dispersion – free channel**.

An estimation of capacity per dimension of MC-CDMA system is

$C_{MC-CDMA} = \frac{1}{2}$ $\log_2$ (if$\int p.T_s/N_o$) [bits per dimension.] …….. (6)

Figure of merit attributes the enhancement of MC-CDMA is Rayleigh fading channel over non fading channel, Lee [4] proposed to estimate the capacity of the Rayleigh fading channel as

$$C_{OFDM} = 2\int_o^\infty f\left(\frac{E_N}{N_o}\right)\frac{1}{2}\log_2\left(1+2\,\frac{E_N}{N_o}\right)d\,\frac{E_N}{N_o} = 2\int_o^\infty \frac{N_o}{P_oT_s}\exp\left(\frac{N_o}{P_oT_s}x\right)\frac{1}{2}\log_2(1+2x)\,dx.. \quad (7)$$

This can be expressed as $C_{OFDM} = \frac{1}{I_{n2}}$ exp $\left(\frac{N_o}{2P_oT_s}\right) E_1\left(\frac{N_o}{2P_oT_s}\right)$ ……… (8)

Capacity of OFDM and Rayleigh fading channel are inserted. For OFDM, the Instantaneous SNR plus ICI ratio is$\Upsilon$. Large SNR, we use

$E_1$ (z) = -$\Upsilon$ – $I_n$z, so

$C_{OFDM} = \frac{-\Upsilon}{2I_n z} + \frac{1}{2\log_2}\left(\frac{2P_oT_s}{N_0}\right)$ ... (9)

OFDM on a Rayleigh – fading channel with local mean SNR PoTs/No has approximately 0.4 bit less capacity per dimension than a non – fading channel with the SNR fixed to PoTs/No. Fig.2 depicts the capacity in bits per dimension under Doppler spreads between OFDM and MC-CDMA versus antenna speed for local mean SNR of 10, 20, and 30 dB.

## 4 SIMULATION RESULTS:

The effect of Doppler at 4GHz carrier frequency is shown in fig.3 the frame duration is 896 micro seconds, with an FFT size of 8192 is considered here. This corresponds to a subcarrier spacing of $f_s$ = 1.17 KHz and a data rate of 9.14 μ symbols/s. Fig 3 depicts are capacity in bits per dimension for OFDM and MC-CDMA versus antenna speeds v for Eb/No of 10, 20 and 30 dB. Mobile speeds and Doppler shifts are shown in table 1. It depicts that Doppler shift increases with mobile speed.

| Mobile Speed | Doppler Shift |
|---|---|
| 10m/Sec (36Kmph) | 130.00Hz |
| 30m/Sec (108Kmph) | 389Hz |
| 80m/Sec (288Kmph) | 966.67Hz |
| 100m/Sec (360Kmph) | 1233.33Hz |
| 150m/Sec (360Kmph) | 1800Hz |

**Table1 Mobile speed and Doppler shift**

Fig .3 are the plots drawn between capacity in bits per dimension for OFDM and MC-CDMA versus antenna speeds. It depicts that which the increase of antenna speed, the channel capacity is better for OFDM them MC – CDMA. The full channel capacity ia achieved in MC-CDMA then is coded OFDM. For large SNR, it has apparently less capacity than for a fixed channel by 0.42 bit per dimension with the 30dB SNR. Lower mobile speeds and large SNR Doppler shift could not affect the channel capacity in both multicarrier systems

Considering the plot drawn in fig 3 for the mobile (antenna) speed of 10m/sec there is no effect on capacity (bits per dimension) of SNR 10dB system irrespective of antenna speed both MC-CDMA and OFDM techniques. For the same speed, if the 20dB system is considered, a slight inconsistency is observed i.e. decrease in bits per dimension is observed. If the 30dB system is considered, a large deviation is observed as the antenna speed is increased from 0 m/s to 10 m/s but OFDM is better MC-CDMA.

From figs 3 as the antenna speed is increased to 30 m/s, 80 m/s, and 100 m/s respectively large deviation is observed as the antenna speed is increased. In the plot, it is observed that OFDM is better than MC-CDMA. it is evident that there is no difference for OFDM and MC-CDMA systems even though SNR is increased. But as the speed is increased from 50 m/s to 120 m/s an unavoidable deviation is observed in the channel capacity (bits per dimension).

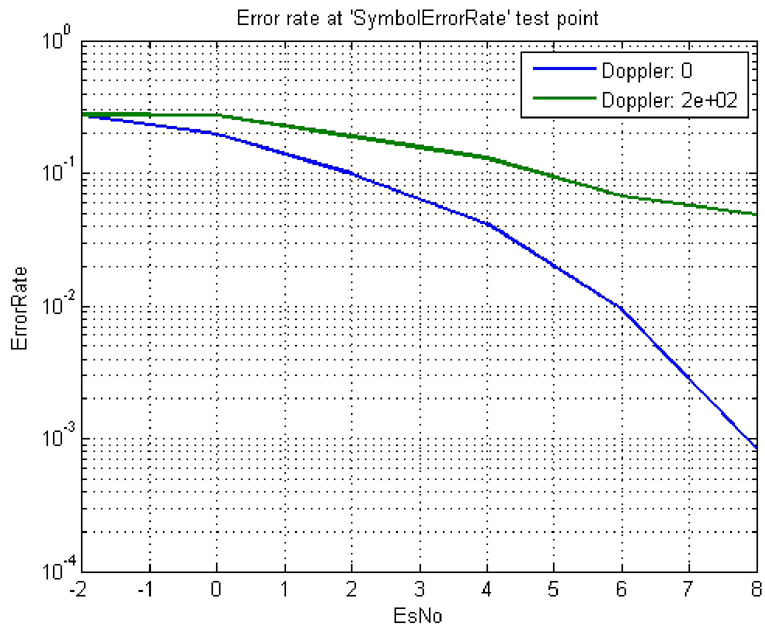


**Fig .2 Rayleigh fading channel with Doppler**

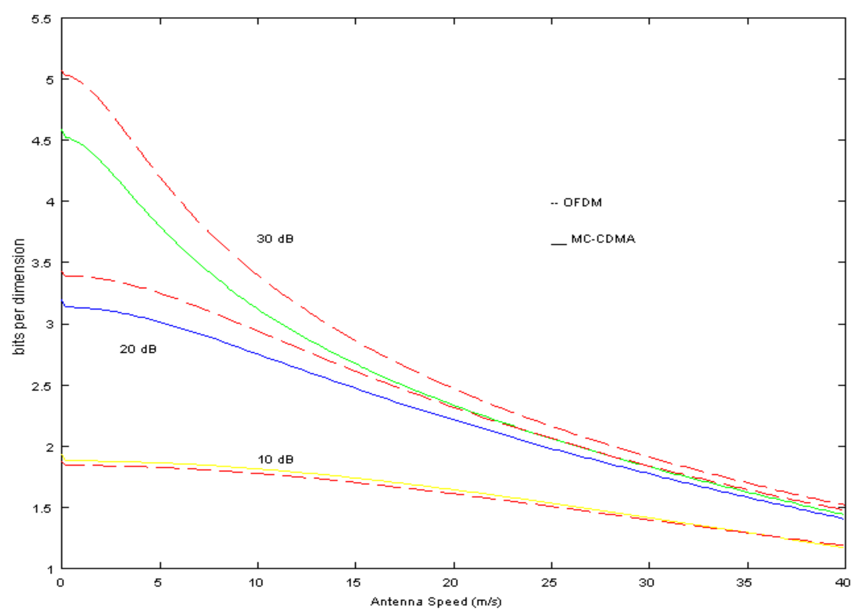


**Fig.3 capacity in bits per dimension for OFDM and MC-CDMA versus antenna mobile speeds 10 m/s to mobile speed 120 m/s.**

## 5. CONCLUSION :

We cannot achieve the full channel capacity in MMSE and MC-CDMA whereas for coded – OFDM high channel capacity can be achieved without fundamental restrictions like ideal error correction, decoding etc. With the increase of antenna speed more than 10m/sec, the channel capacity falls for both OFDM and MC-CDMA due to the increase in Doppler spread. The advantages of MC-CDMA is its high SNR than OFDM is its cause in implementation with error coding simpler then C-OFDM. MC-CDMA has apparently less capacity 0.4 bit per dimension than OFDM with the low SNR.

Lower mobile speeds and low SNR Doppler shift could not affect the channel capacity in both the multicarrier systems. Doppler spread creates more degrade in the performance of the receiver. This Doppler spread effect can be minimized by using adaptive equalization techniques. Signal strength is estimated as measure of channel capacity and Doppler speed and studies predict that it various linearly with mobile speed.

## References:

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