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# Performance Analysis of OFDM Using LTE Systems

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**ABSTRACT**
In this paper, we analyze the OFDM system using LTE. Here LTE Advanced is used to meet the requirements of LTE.ICI is one term which limit the Performance of OFDM. Timing jitter and I/Q imbalance are other front end impairments of OFDM. Based on the variations of amplitude and Phase imbalance, ICI to signal power ratio is calculated and SINR is calculated for various amplitude imbalance. Here the concept of time sharing is generated in between transmitter and receiver which reduce latency in wide band transmission lines.

**Key terms:** OFDM, Timing Jitter, ICI,I/Q imbalance, LTE, LTE Advanced.

## I. INTRODUCTION

The receiver of a typical OFDM system [1] requires a quadrature down-converter to translate an RF or optical signal into in-phase (I) and quadrature (Q) baseband signals. However, imperfections in the analog Local Oscillator (LO) of the receiver

May mean that the amplitudes of the local I and Q carriers are not equal and/or the phase difference is not exactly 90 degrees. This is called I/Q imbalance. The mismatches of amplitude and phase shift are called amplitude and phase imbalance, respectively. The impact of I/Q imbalance in OFDM systems has been studied and a bit-error rate (BER) analysis was given . Compensation schemes are described in.

However the interactions between timing jitter and I/Q imbalance have not been investigated before. Timing jitter and I/Q imbalance are important front-end impairments in the new optical OFDM systems, so the interactions of timing jitter and I/Q imbalance are potentially important. In this paper we study the combined effect of I/Q imbalance and timing jitter. Since the launch of third-generation (3G) mobile communications services, high-speed wireless access services that provide high-speed data transmission in a mobile environment have come to be used in diverse applications including E-mail and Web access using a mobile

Phone. Transmission bit rates of 7.2 Mb/s have recently been achieved in cellular systems, and Worldwide Interoperability for Microwave Access (WiMAX) services, which aim for even higher bit rates, have been launched. In this paper, we describe the current state of the Long Term Evolution (LTE) and WiMAX systems for achieving high-speed mobile wireless access services, discuss trends toward future bitrates Enhancements and achieve better spectral efficiency.

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## II. EXISTING METHOD

**Orthogonal frequency-division multiplexing** (**OFDM**) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, power line networks, and 4G mobile communications. OFDM is essentially identical to **Coded OFDM** (**COFDM**) and **discrete multi-tone modulation** (**DMT**), and is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. The word "coded" comes from the use of forward error correction (FEC).[1] A large number of closely spaced orthogonal sub-carrier signals are used to carry data[1] on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

**Characteristics and principles of operation**

**Orthogonality**

Conceptually, OFDM is a specialized FDM, the additional constraint being: all the carrier signals are orthogonal to each other.

In OFDM, the sub-carrier frequencies are chosen so that the sub-carriers are orthogonal to each other, meaning that cross-talk between the sub-channels is eliminated and inter-carrier guard bands are not required. This greatly simplifies the design of both the transmitter and the receiver; unlike conventional FDM, a separate filter for each sub-channel is not required.

**Analysis of Timing jitter and I/Q imbalance in OFDM**

In the analysis of OFDM in AWGN Channel timing jitter an I/Q imbalance are each front end impairments.

By analyzing it combined we have employed oversampling technique [6],[2] where some band edge carriers are left unused or removed. Here **γ** is another parameter which is varied for different variations in amplitude and phase imbalances. It is however more sensitive to multipath interference. The signal to be transmitted is written in composite matrix form as follows

$$Y = \alpha WHX + \beta W H^{*} X^{*}_{m} + N \qquad (1)$$

Where

$$\alpha = \cos(\theta/2) + j(\varepsilon/2)\sin(\theta/2) \qquad \beta = \varepsilon/2\cos(\theta/2) - j\sin(\theta/2)$$

$$\mathbf{Y} = \begin{bmatrix} Y_{-N/2+1} & \cdots & Y_0 & \cdots & Y_{N/2} \end{bmatrix}^{\mathrm{T}},$$

$$\mathbf{X}^{*}_{m} = \begin{bmatrix} X^{*}_{N/2} & \cdots & X^{*}_{0} & \cdots & X^{*}_{-N/2+1} \end{bmatrix}^{T},$$

$$\mathbf{W} = \begin{bmatrix} w_{-N/2+1,-N/2+1} & \cdots & w_{-N/2+1,N/2} \\ \vdots & \ddots & \vdots \\ w_{N/2,-N/2+1} & \cdots & w_{N/2,N/2} \end{bmatrix}$$

$$\mathbf{N} = \begin{bmatrix} N_{-N/2+1} & \cdots & N_0 & \cdots & N_{N/2} \end{bmatrix}^{T}.$$

Here the elements of W are given as below

$$w_{l.k} = \frac{1}{N}\sum_{n=-N/2+1}^{N/2} \exp\left(\frac{2\pi k}{T}\left(\frac{nT}{N} + \tau_n\right)\right)\exp\left(\frac{-j2\pi nl}{N}\right) \qquad (2)$$

After adding noise components like timing jitter and I/Q imbalance in received signal [3] is by

$$Y = \alpha HX + \alpha(W - I) + \beta W H^{*} X_{m}^{*} + N \qquad (3)$$

Here the above (3) can also be written as

$$Y = \cos(\theta/2)HX + j(\varepsilon/2)\sin(\theta/2)HX + \alpha(W - I)HX + \beta(W - I_m)H^{*}X_{m}^{*} + \beta H^{*}X^{*} + N \qquad (4)$$

After assuming in AWGN channel [4] is assumed as below equation

$$P_{\text{jitter}+\theta+\varepsilon} = E\left\{\left|j\left(\varepsilon/2\right)\tan\left(\theta/2\right)\sum_{k=-N/2+1}^{N/2}\left(w_{l,k}-I_{l,k}\right)X_k\right|^2\right\} + E\left\{\left|\left(\varepsilon/2\right)\sum_{k=-N/2+1}^{N/2}\left(w_{l,k}-I_{l,-k}\right)X_{-k}^*\right|^2\right\} + E\left\{\left|-j\tan\left(\theta/2\right)\sum_{k=-N/2+1}^{N/2}\left(w_{l,k}-I_{l,-k}\right)X_{-k}^*\right|^2\right\}.$$

Then finally ICI noise to signal power is given as

$$\gamma=\frac{P_{\text{total}}}{\sigma_s^2}=\left\{\left(1+(\varepsilon/2)^2\tan^2(\theta/2)+(\varepsilon/2)^2+\tan^2(\theta/2)\right)\times\frac{1}{6}\pi^2\bar{\sigma}_j^2\right\}+\tan^2(\theta/2)+(\varepsilon/2)^2+(\varepsilon/2)^2\tan^2(\theta/2) \tag{5}$$

OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal, causing Inter-Carrier Interference (ICI) (i.e., cross-talk between the sub-carriers). Frequency offsets are typically caused by mismatched transmitter and receiver oscillators, or by Doppler shift due to movement. While Doppler shift alone may be compensated for by the receiver, the situation is worsened when combined with multipath, as reflections will appear at various frequency offsets, which is much harder to correct. This effect typically worsens as speed increases,[2] and is an important factor limiting the use of OFDM in high-speed vehicles. In order to mitigate ICI in such scenarios, one can shape each sub-carrier in order to minimize the interference resulting in a non-orthogonal subcarriers overlapping. Drastically the receiver complexity Here time delays occurring in between transmitter to receiver will affect to all transmission lines when it is used in Wide band Transmission.

## III. PROPOSED METHOD

**Long Term Evolution (LTE)** is another concept which is introduced in wide ban Transmission mainly in mobile communication to achieve the better spectral efficiency and cell coverage.[17]

LTE Advanced is one which is introduced to meet requirements of LTE.It should be backward compatibility with LTE.LTE is developed by the 3rd Generation Partnership Project(3GPP) and CDMA 2000 1x and Ultra Mobile Broadband(UMB) specified by 3GPP2..

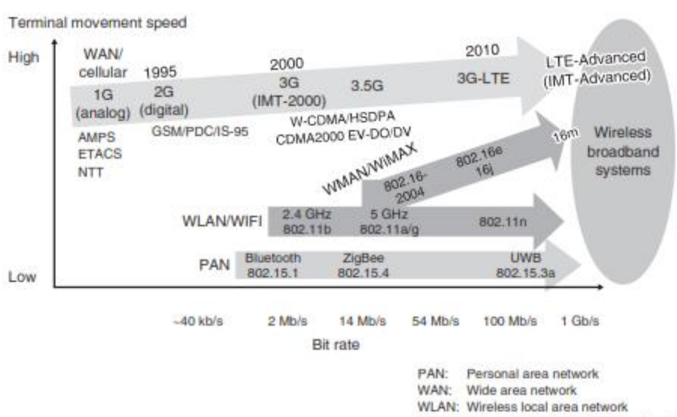



**Fig.1.Trends of mobile communication systems**

The systems that have been developed so far providing high speed mobile wireless access services are High Speed Packet Access (HSPA)

**Table 1: Basic requirements of 3.9G mobile communication systems**

| | |
|---|---|
| Maximum bit rate | Downlink: 100 Mb/s or greater<br>Uplink: 50 Mb/s or greater |
| Spectrum usage efficiency | ≥3 (downlink), ≥2 (uplink) times 3.5G (HSPA release 6) |
| Occupied bandwidth | Scalable bandwidth |
| Network | All-IP network |
| Extendibility to future systems | Smooth extendibility to 4G mobile communications system |
| Transmission quality | Shorter delay than current 3.5G |
| Global scope | International roaming and interoperability |

LTE and those currently being discussed for LTE-Advanced in 3GPP are outlined below.
Techniques are introduced in LTE Advanced to get better throughput at cell edge, decrease latency and increase cell coverage. Efficient multiple access technology is taken as key point: In the downlink, LTE uses OFDM LTE uses single-carrier Frequency Division Multiple Access(FDMA), whose transmit signal retains a small peak-to-average power ratio. Here Signal to Interference + Noise ratio is increased by employing some Comp transmission Schemes and relaying**, carrier** aggregation etc are used. Here in Comp Transmission several antennas are proximity to one another. Here spectral efficiency is achieved using multiple antenna technology. Using coordinate Scheduling an beam forming better throughput is achieved. Figure below shows Comp transmission in down link.

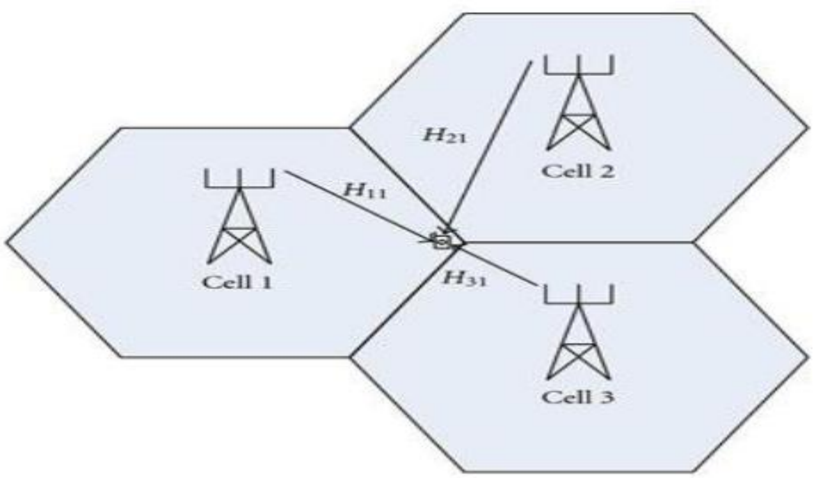
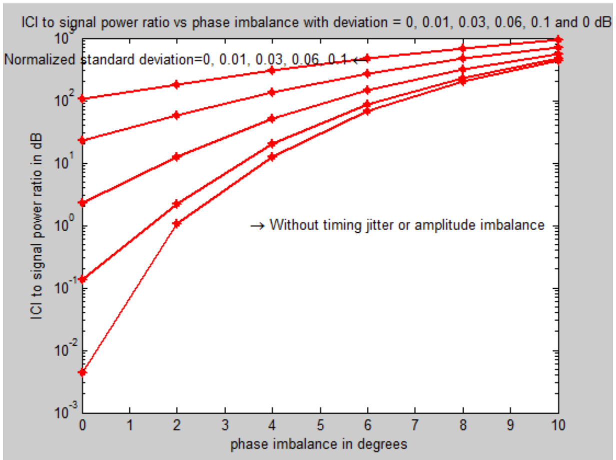


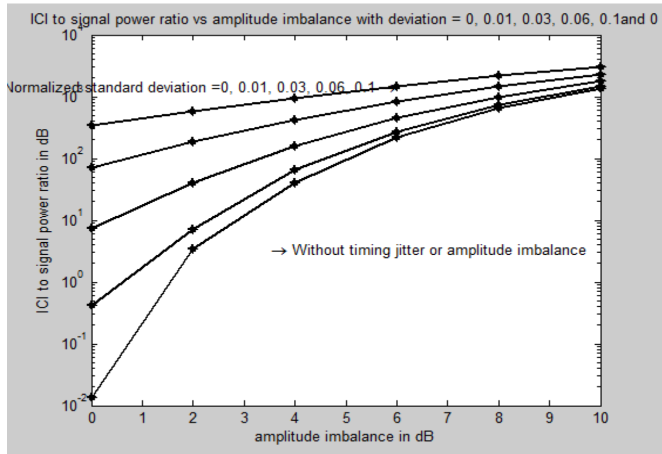

**Figure 3.1 Comp transmission/ Reception in downlink**

## IV.EXPERIMENTAL RESULTS

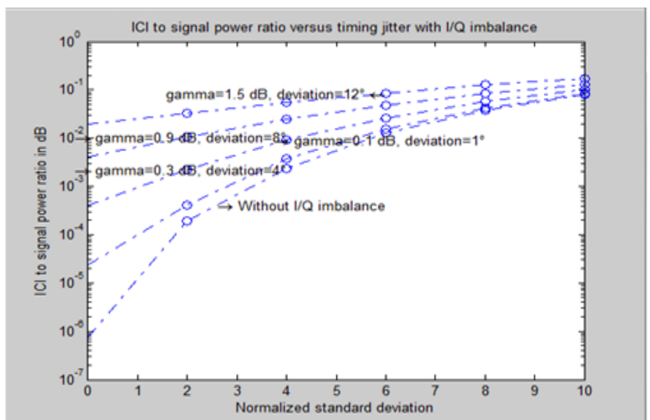
**Here γ=ICI to signal power ratio**



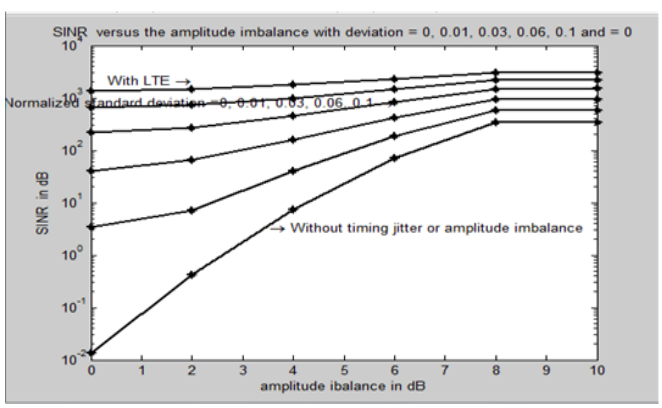

**(a)**




**(b)**




**(c)**




**(d)**

**Fig.1.Energy efficiency for OFDM & LTE (a)γ vs Phase imbalance,(b) )γ vs Amplitude imbalance, (c) )γ vs Timing jitter by I/Q Imbalance,(d)SINR vs Amplitude imbalance**

## V. CONCLUSION

Here, in this paper ICI to signal power ratio is evaluated for different timing jitter and I/q imbalances. Phase imbalances have a less effect than timing jitter and Amplitude imbalance. By using LTE better throughput is achieved and spectral efficiency is improved with increase in SINR.

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