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Simulation of OFDM System in LTE

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ABSTRACT:

LTE is specified by the 3rd generation partnership project as a standard for high speed data transfer in 4th generation wireless communication networks. OFDM is the transmission scheme used for 3GPP LTE. This paper provides the simulation of OFDM block diagram in Matlab used for LTE. LTE downlink take advantage of OFDM technology by using OFDMA.

Keywords: 3GPP, LTE, OFDM, OFDMA

1. INTRODUCTION:

Advancement in wireless technology has been increasing day by day. At the end of 1998, the Third Generation Partnership Project (3GPP) was formed by standards developing organizations from all regions of the world. 3GPP published and introduced the various standards for IP based system in Release 8, which was also termed Long Term Evolution and abbreviated as LTE. Recently, in 2011, LTE was further developed through Release 10 to satisfy ITU's IMT-Advanced requirements for 4G cellular systems. LTE is capable of supporting up to 1Giga bits per second (1Gbps) for fixed user and up to 100 Mega bits per second (100Mbps) for high speed user [1]. The prime cause of this high speed of LTE systems is the advancement in physical layer. OFDM is the transmission scheme used for 3GPP LTE. Wireless cellular systems are multiuser systems today. Multiple users can take the advantage of OFDM technology by using Orthogonal Frequency Division Multiple Access (OFDMA) technique.

2. OFDM:

In OFDM, the signals to be transmitted are constructed in such a way that the frequency spectra of individual sub-channels are allowed to overlap; thereby, utilising the frequency spectrum much more efficiently. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other. OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form (e.g. voice and data) is applied to any of these carriers, then sidebands spread out either side as shown in Figure 1. These sidebands from each carrier overlap. However in OFDM scheme, these can be received without interference as these are orthogonal to each other. IEEE 802.16d (fixed service) uses Orthogonal Frequency Division

Multiplexing; whereas, IEEE 802.16e (mobile) uses Orthogonal Frequency Division Multiple Access.

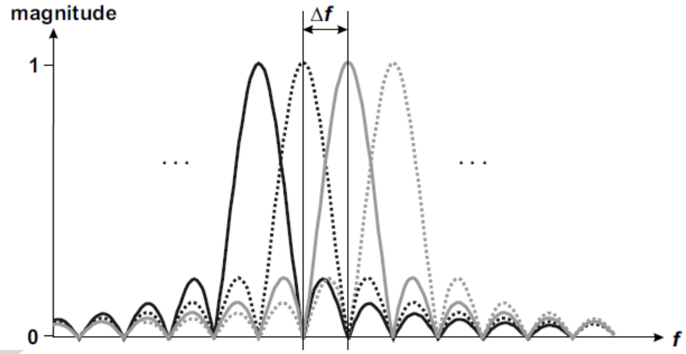

Figure 1: OFDM signal representation [2].

Mathematically, the two periodic signals are orthogonal when the integral of their product over a period is equal to zero. This can be represented in continuous time as:

$$\int_0^t \cos(2\pi f_0 nt)\cos(2\pi f_0 mt)\,dt = 0 \tag{1}$$

For the case of discrete time, it can be represented as:

$$\sum_{k=0}^{N-1} \cos\left(\frac{2\pi kn}{N}\right)\cos\left(\frac{2\pi km}{N}\right) dt = 0 \tag{2}$$

where, $m \neq n$ in both cases. As mentioned above, each subcarrier in an OFDM system is a sinusoid with a frequency that is an integral multiple of fundamental frequency. Each subcarrier can be expressed as a Fourier series component of the composite signal, i.e. an OFDM symbol. The subcarriers waveform can be mathematically expressed as:

$$s(t) = \cos(2\pi f_c t + \theta_k) = a_n \cos(2\pi n f_0 t) + b_n \sin(2\pi n f_0 t) \tag{3}$$

where, $\varphi_n = \tan^{-1}(b_n / a_n)$. The sum of these subcarriers is then referred to baseband OFDM signal as:

$$s_b(t) = \sum_{n=0}^{N-1} \{a_n \cos(2\pi n f_0 t) - b_n \sin(2\pi n f_0 t)\}\ cdvdbv \tag{4}$$

These large numbers of closely spaced orthogonal subcarriers are used to carry data.

3. Simulaing OFDM system in Matlab: Block diagram of OFDM system is shown in Figure 2.

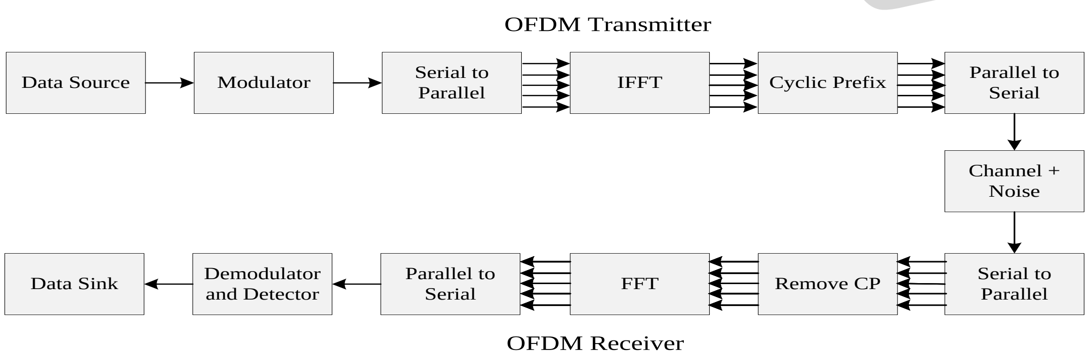

Figure 2: Block diagram of an OFDM system.

Each block of OFDM system is implemented in Matlab. Parameters for OFDM implementation in Matlab is given in Table 1 and results are depicted from Figure 3 to 14.

Table 1: Parameters for OFDM implementation in Matlab.

PARAMETERS	DETAILS
Length of data	10000
Modulation scheme	64QAM
Size of OFDM	64
FFT size	64
Cyclic Prefix length	7

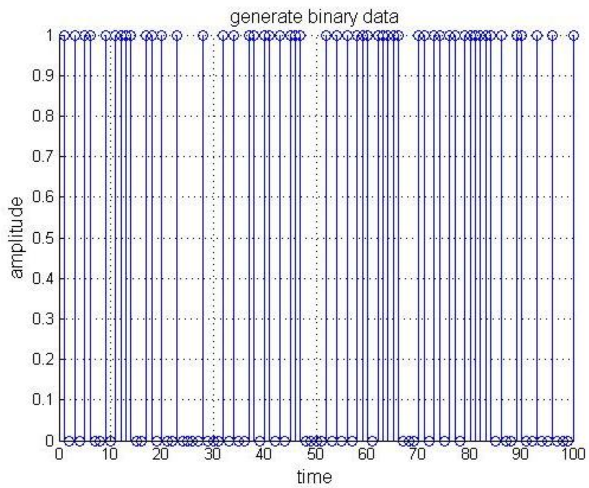

Figure 3: Generating Binary data.

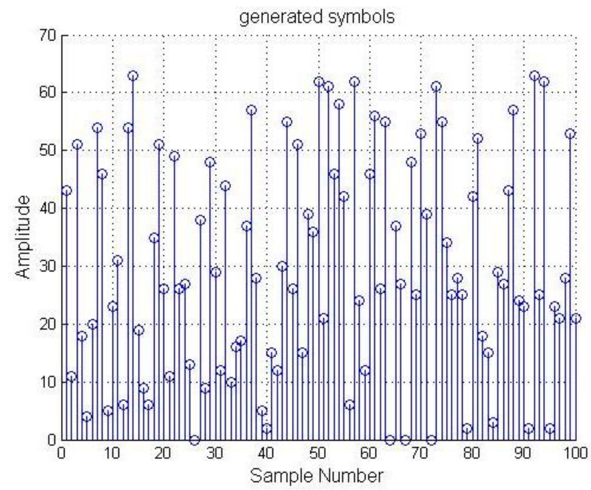

Figure 4: A typical example of generated symbols.

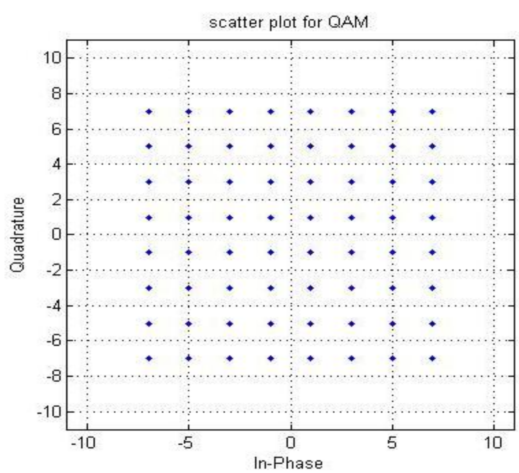

Figure 5: Scatter plot for 64 QAM.

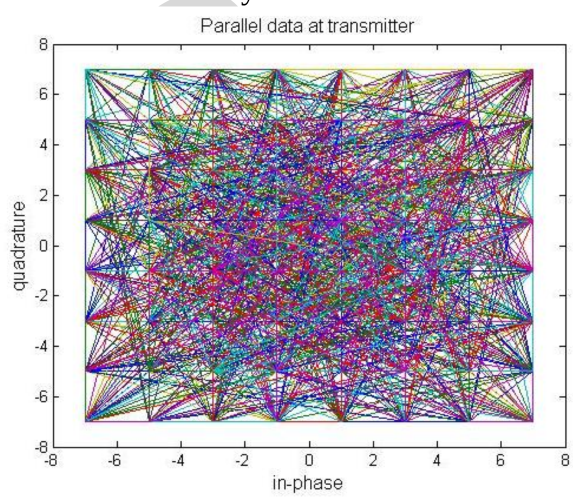

Figure 6: Parallel data at transmitter.

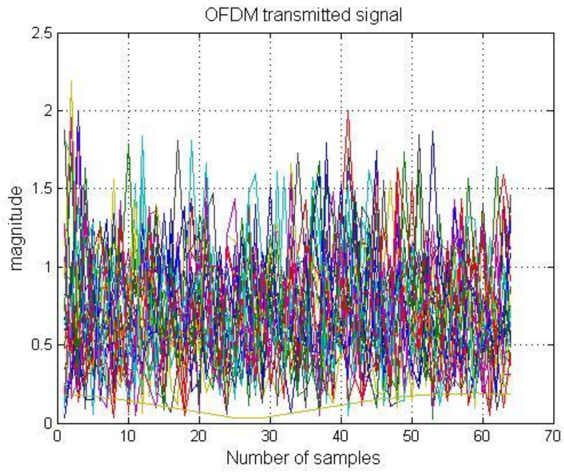

Figure 7: Parallel OFDM signal before transmission.

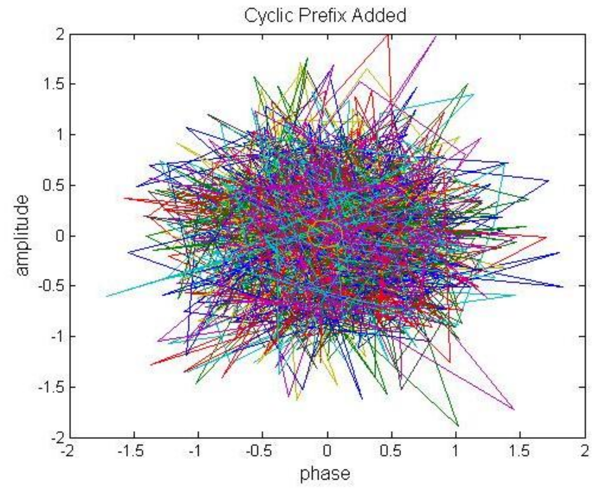

Figure 8: Cyclic Prefix added.

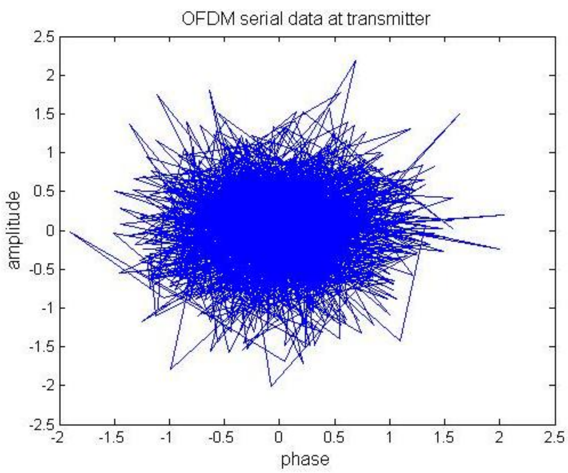

Figure 9: OFDM serial data at transmitter.

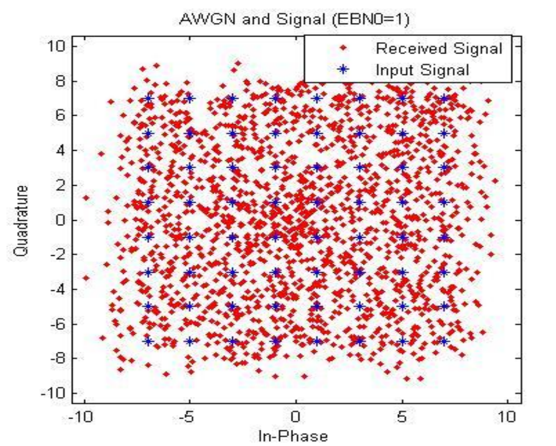

Figure 10: QAM modulated awgn noisy input signal with constellation size 64.

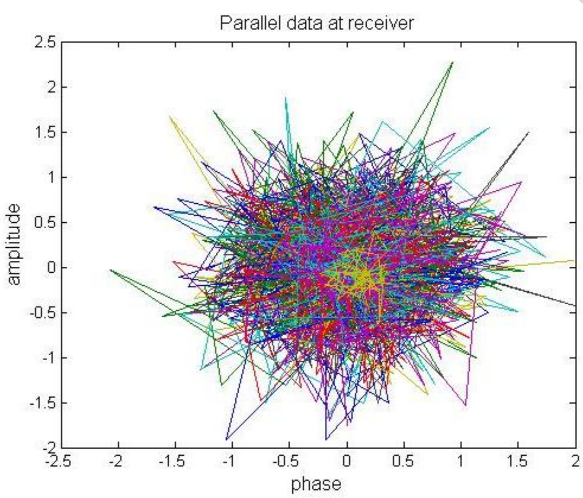

Figure 11: Parallel data at receiver.

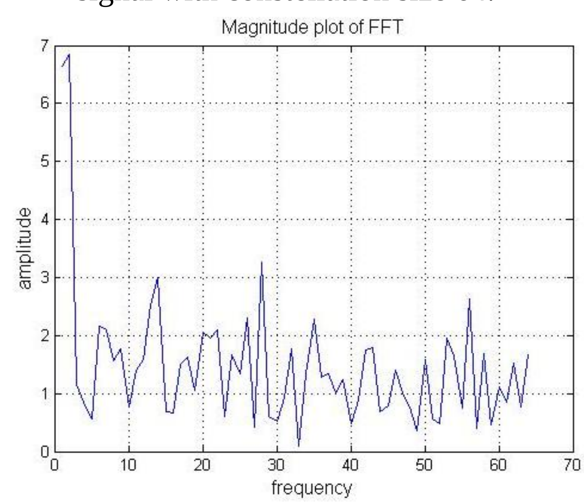

Figure 12: FFT plot of OFDM signal.

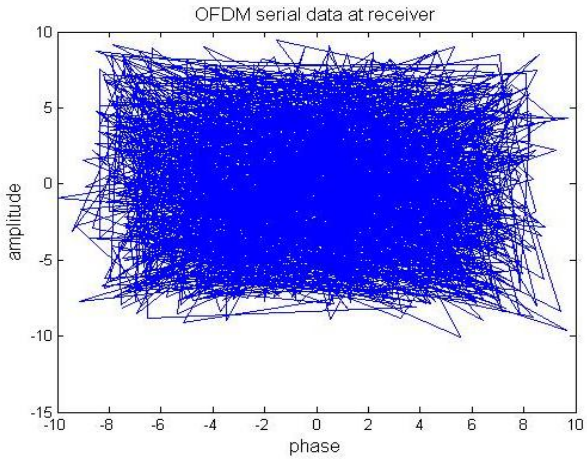

Figure 13: OFDM serial data at receiver.

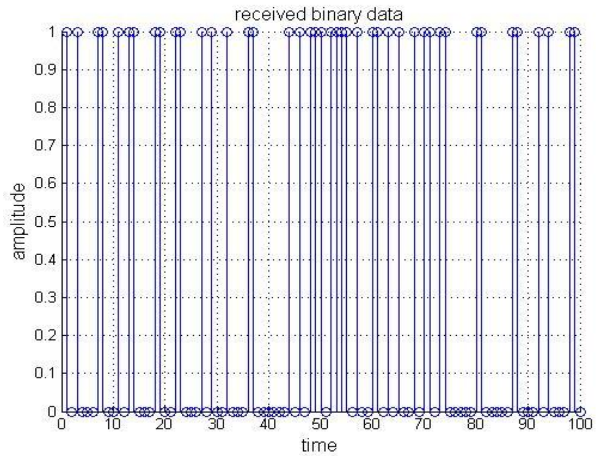

Figure 14: Received binary data.

4. CONCLUSION: Each block of OFDM block diagram is implemented and signals at each step/block is visualized. It is found that the same data was received, that was transmitted.

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