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FPGA Implementation of LTE Downlink Transceiver with Synchronization and Equalization

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ABSTRACT

Long Term Evolution (LTE) is an advanced standard of the mobile communication systems. LTE has been developed by the 3rd Generation Partnership Project (3GPP). The new features exhibited by LTE is a direct impact of applying new modulation and coding techniques such as the Orthogonal Frequency Division Multiplexing (OFDM) for the Downlink and the Single Carrier Frequency Division Multiple Access (SC-FDMA) for the Uplink as well as turbo coding. This paper presents a Field Programmable Gate Array (FPGA) design and implementation of the LTE downlink transmitter and receiver according to releases 8 and 9 on Virtex 6 XC6VLX240T FPGA kit using Xilinx® ISE® Design Suite version 12.1. It is found that the utilization of the look up tables and flip flops amounts to about 65 percent while the other logic devices utilization on the chip amount to only 5–13 percent. Such implementations can be considered as IPs for software defined radios. The information is also useful for the FPGA developers. The most important consequence is that the FPGA vendors may produce more appropriate counts of the resource blocks for better the utilization of the chips used in the LTE transceivers.

Keywords

LTE, 4G, 3GPP, OFDM, 2G ,3G, LTE downlink physical layer, release 8, release 9 *Xilinx Design Suite, virtex 6 XC6VLX240T FPGA.*

1. INTRODUCTION

The Long Term Evolution (LTE) is an advanced standard for wireless voice and data communication.. The 3GPP standards' bodily has completed definition of the first release of the LTE system, The main advantages of the LTE, also known as 4G, over the 2G and 3G systems are utilizing a higher peak data rates by providing for an uplink speed of up to 50 megabits per second (Mbps) and a downlink speed of up to 100 Mbps. LTE will bring many technical benefits to cellular networks. Bandwidth will be scalable from 1.25 MHz to 20 MHz. This will suit the needs of different network operators that have different bandwidth allocations, and also allow operators to provide different services based on spectrum. LTE also improved spectral efficiency up to 5 bps/Hz for Downlink and 2.5 bps/Hz for Uplink, allowing carriers to provide more data and voice services over a given bandwidth.

The LTE physical layer (PHY) is a highly efficient means of conveying both data and control information between an enhanced base station (eNodeB) and mobile user equipment (UE). The LTE PHY layer employs some advanced technologies that are new to cellular applications. These include Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO) data transmission. In addition, the LTE PHY layer uses Orthogonal Frequency Division Multiple Access (OFDMA) on the downlink (DL) and Single Carrier – Frequency Division Multiple Access (SC-FDMA) on the uplink (UL). OFDMA allows data to be directed to or from multiple users on a subcarrier-by-subcarrier basis for a specified number of symbol periods. Due to the novelty of these technologies in cellular applications, they are described separately before delving into a description of the LTE PHY layer.

LTE uplink requirements differ from downlink requirements in several ways. Not surprisingly, power consumption is a key consideration for UE terminals. The high PAPR and related loss of efficiency associated with OFDM signaling are major concerns. As a result, an alternative to OFDM was sought for use in the LTE uplink.

Single Carrier – Frequency Domain Multiple Access (SC-FDMA) is well suited to the LTE uplink requirements. The basic transmitter and receiver architecture is very similar (nearly identical) to OFDMA, and it offers the same degree of multipath protection. Importantly, because the underlying waveform is essentially single-carrier, the PAPR is lower [1-5].

The continued increase in the number of users of mobile communications all over the world, motivated researchers to search for a unified wireless platform. This will enable the mobile users to conduct business and exchange data easily while moving elsewhere in the world. The new features of LTE made it the promising platform intended for the advancements in mobile communications [6].

In the last few years, technology evolution in mobile communications is mainly motivated by two relevant agents: (1) the market globalization and liberalization and the increasing competence among vendors and operators coming from this new framework, (2) the exponential increase in the demand for advanced telecommunication services and we note that the computational framework and the insights gained via the numerical studies can be extended to other orthogonal division frequency multiple access (OFDMA) technologies. For that the many researchers are concerned with the development of implementation methods and techniques for the building blocks of the LTE physical layer. So, an extensive research work is directed to the implementation of the building blocks of this system using different platforms [7-10].

This paper presents the simulation and the FPGA implementation of the LTE downlink physical layer (on Virtex 6 XC6VLX240T FPGA kit) according to release 9 using Xilinx package version 12.1. Every stage in both the transmitter and receiver are implemented, and verified. The paper is organized such that section 2 presents the full detailed description of the building blocks of the LTE transmitter and

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