BER, SNR and PAPR Analysis of OFDMA and SC-FDMA

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Abstract: *Communication between the transmitter and receiver is made possible by wireless communication, which is seen as the future trend. In order to send the signal through the channel, the signal has been modified after it is generated in each of the multiple sub carriers. Modulation schemes Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier Frequency Division Multiple Access (SC-FDMA) and others are compared. OFDM was used earlier, but it had a lot of disadvantages, such as Doppler shift issues and frequency synchronization problems, Power efficiency is low and peak to average ratio (PAPR) is high. In Long-Term Evolution (LTE), the downlink and uplink technologies are OFDMA and SC-FDMA, respectively. OFDMA and SC-FDMA transceiver are described in this paper along with their differences.*

Keywords: *OFDM, OFDMA, SC-FDMA. Long Term Evolution (LTE), Single Carrier Frequency Division Multiple Access (SC-FDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Additive White Gaussian Noise (AWGN)*

1.INTRODUCTION

In recent wireless communication, we highly recommend a high speed and preferred throughput. The popularity of wireless communication has grown from decades prior to the high-speed wired communications. There are various ways in which wireless communication degrades, including small scale fading, large scale fading, distortion, and HPA nonlinearities [1]. In order to meet these requirements, single carrier transmission is replaced with multiple carrier transmission. For high-speed transmissions and voice communications, multiple transmission schemes like orthogonal frequency division multiplexing (OFDM) are used [2].

OFDM has been used for downlink communication in wireless networks. The difficult channel conditions can easily adopt these channels. This eliminates the need for complex time domain equalization [3]. In terms of 4G wireless communications, OFDM is a good candidate. Multipath fading is effectively prevented, and bandwidth efficiency is increased. By increasing the system capacity, it also ensures reliable transmission [4]. The main disadvantage of OFDM is the high PAPR [5]. PAPR can be reduced using several techniques. For communication or transmission, OFDM features give rise to SC-FDMA. As a wireless network's uplink, SC-FDMA replaces OFDM. With its low carrier frequency offset sensitivity and less PAPR, it has many useful properties.

Wireless data networks using various modulations can be made more sensitive and faster with Long Term Evolution (LTE). A significantly diluted transfer latent period is one of the benefits of LTE [6]. Using the OFDMA scheme, it supports downlink transmission up to 300 mbps and SC-FDMA, uplink transmission up to 75 mbps. Using OFDMA, data is transmitted over a wide range of subcarriers [7]. The two most common Frame Structures used in LTE are Frequency Division Duplex (FDD) and Time Division Duplex (TDD). In this study, we analyze the performance of OFDMA and SC-FDMA in various modulation techniques.

Section 2 describes OFDMA System Model; Section 3 provides information about the SC-FDMA System Model. In section 4, Simulation results are given and we finally conclude in Section 5.

2. OFDMA System Model

In Figure 1, we see an OFDMA model. A serial-to-parallel converter converts input data received from the transmitter into parallel data [8]. Several modulation schemes such as 16-QAM, 64QAM, QPSK, etc. are then used to map each carrier's input data stream. An Inverse Fast Fourier Transform, which performs an N-point IFFT operation on M symbols, is then used to determine the corresponding Time waveform [6]. In this case, we are getting output is N time samples [9]. Adding cyclic extension to the prefix before each sample creates the Guard interval. A parallel to serial converter is used to translate the cyclically extended symbols into serial signals that are transmitted over a channel [10]. The transmitted signal is then modeled using a channel model. It is possible in the model to control the signal to noise ratio, as well as multipath. AWGN is used to set the signal to noise ratio by adding a known amount of white noise to the transmitted signal [11]. Receivers function like transmitters in reverse. In addition, cyclic extension is removed from the transmitted signals, which are then converted using a Serial to Parallel converter. Transform of time domain signal at each N points into frequency domain is achieved by the N-point Fast Fourier Transform. Using the Parallel to serial convert block, the signal is demapped and converted to M samples using parallel to serial conversion [8].

OFDM and OFDMA operate very similarly, however the base station allocates each user a subset of carriers rather than the full number of carriers in order to allow multiple transmissions to take place at once. Comparing OFDMA to OFDM, it has the disadvantage of being highly sensitive to frequency offsets. Due to the fact that each subcarrier's frequencies came from a single transmitter, it is relatively simple to maintain orthogonality. OFDMA tends to cause a frequency offset because many users transmit simultaneously with their own estimates of subcarrier frequencies. Therefore, users power is leaked into subcarrier bands, causing multiple access interference [12].

3. SC-FDMA System Model

Figure 2 shows a model of SC-FDMA. SC-FDMA has a higher DFT processing rate than OFDMA. SC-FDMA is therefore a DFT-spread OFDMA in which time domain data signals are first converted into frequency domain by a DFT and then modulated by OFDM [13]. A single carrier symbol is first modulated using QPSK, 16-QAM or 64-QAM from the input data stream. SC-FDMA uses modulated symbols as inputs for its functional blocks. A number of parallel symbols are then generated, and the modulated symbols are organized into blocks. A N-point DFT that converts time domain signals into discrete frequency tones. After that, Subcarrier Mapping governs frequency assignment, mapping discrete frequency tones to N subcarriers for transmission. Local or distributed mapping is possible. A distributed mapping for N-discrete frequencies maps N-discrete frequencies on uniformly spacing sub-carriers, while a localized mapping maps N-discrete frequencies on consecutive subcarriers. This is then followed by M-Point IDFT's conversion to time domain. A zero value is assigned to unused inputs if M > N. A system that uses a single carrier with frequency domain equalization is equivalent to a conventional single user single carrier system if they are equal in number (M = N). Parallel time domain subcarriers are then converted to serial time domain subcarriers. ISI is avoided by adding the CP prefix. So that ISI doesn't occur at the receiver, the length of CP is greater than the channel delay spread. SC-FDMA receivers do the inverse of SC-FDMA transmitters after passing through channels [6].

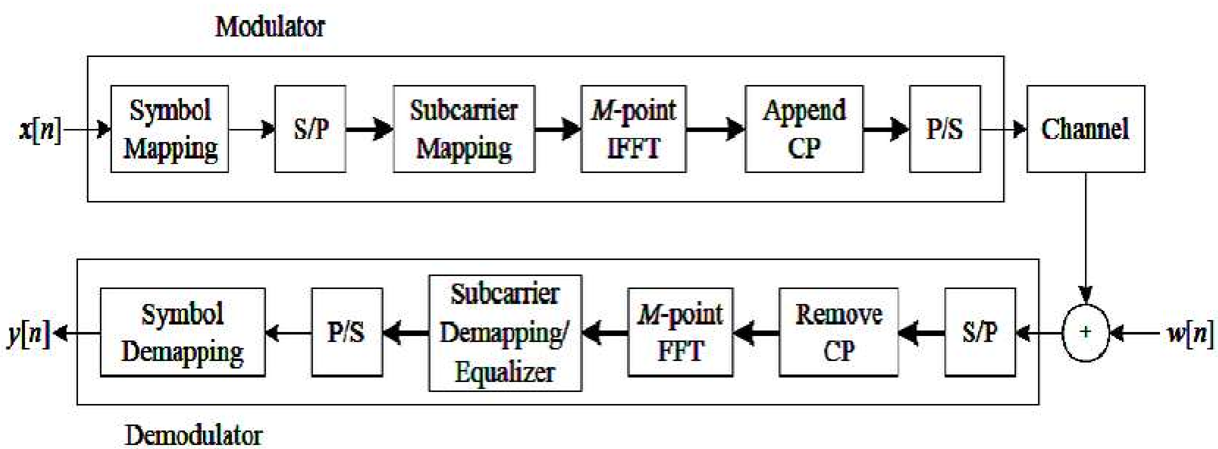

Figure 1. System Model of a downlink OFDMA System

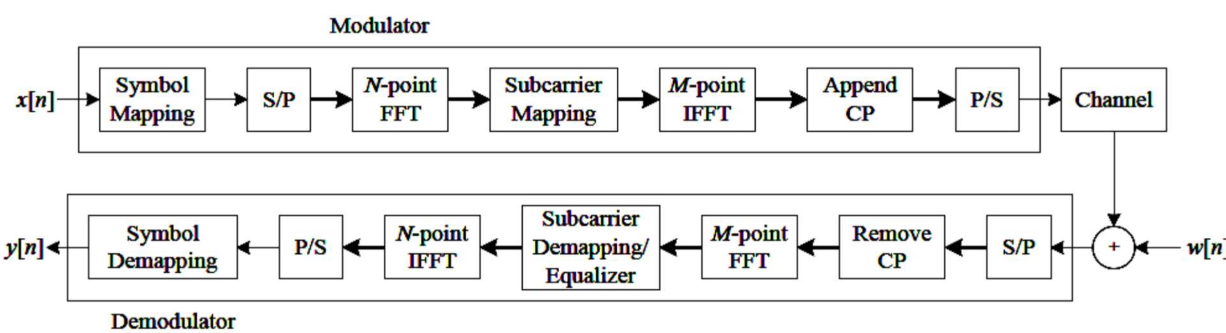

Figure 2 . Block diagram for SC-FDMA

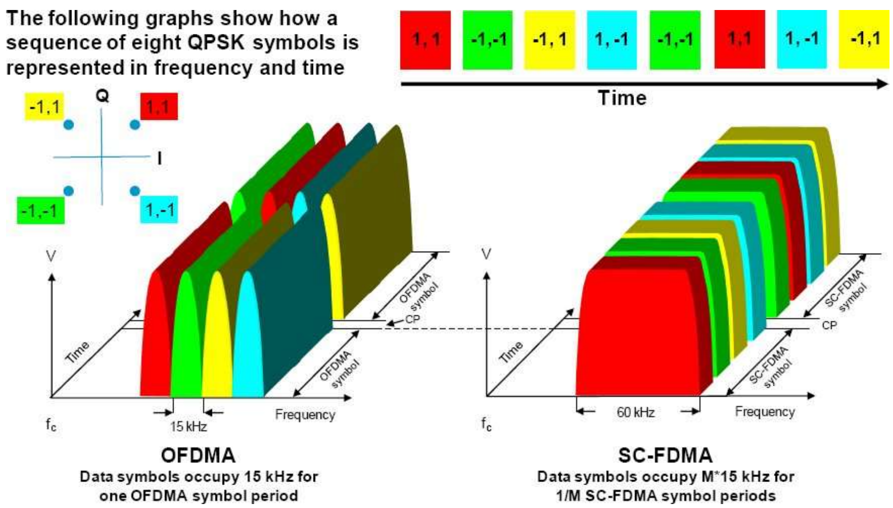

Fig 3 .ODFDMA and SC-FDMA Subcarrier allocation

4. SIMULATION RESULTS

An OFDMA and SC-FDMA system with AWGN channel was evaluated for its SER and PAPR performance. As a result of its robustness against interference from multiple carriers, LFDMA has better SER performance than IFDMA and DFDMA techniques, shown in figure 5. LFDMA and DFDMA almost have the same PAPR performance. LFDMA and DFDMA are less efficient than IFDMA in OFDMA, shown in fig 7. It has been observed that LFDMA, IFDMA, and DFDMA perform almost similarly in terms of SER. LFDMA and DFDMA almost have the same PAPR performance in SC-FDMA. The performance of IFDMA in SC-FDMA is better than that of LFDMA and DFDMA, figure 8. We measure BER, SNR, and PAPR performance of both OFDMA and SC-FDMA systems over multipath channels with AWGN. SC-FDMA provides a higher level of performance than OFDMA.

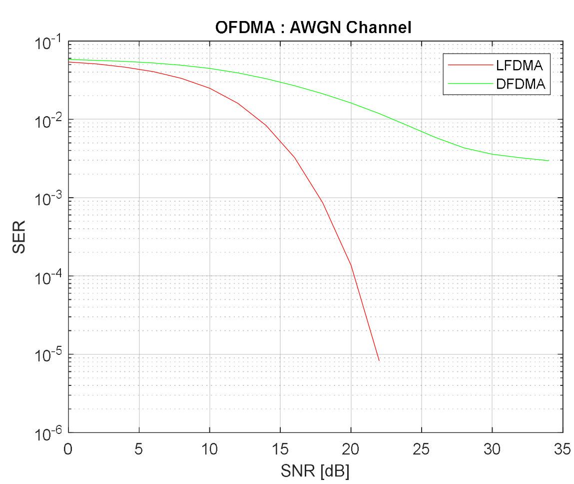

Figure 4 OFDMA : SNR vs SER in AWGN Channel

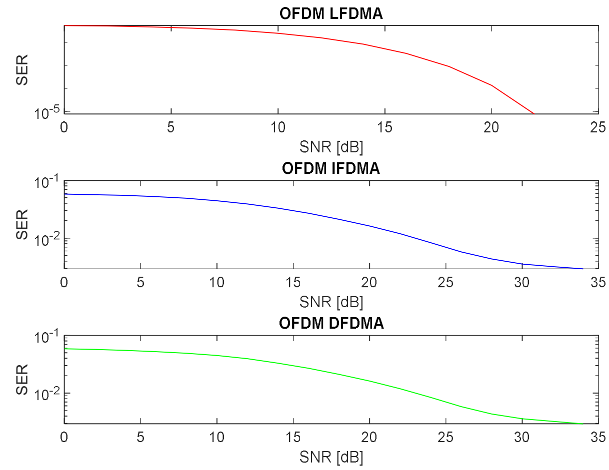

Figure 5 : SNR vs SER for OFDMA in AWGN Channel using LFDMA, IFDMA and DFDMA

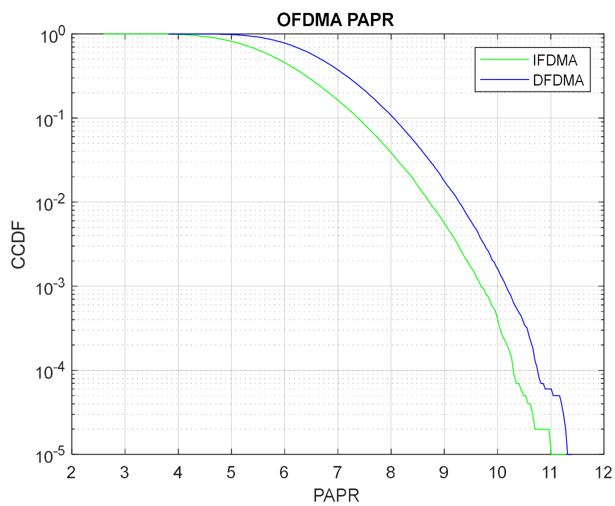

Figure 6. PAPR : IFDMA vs DFDMA

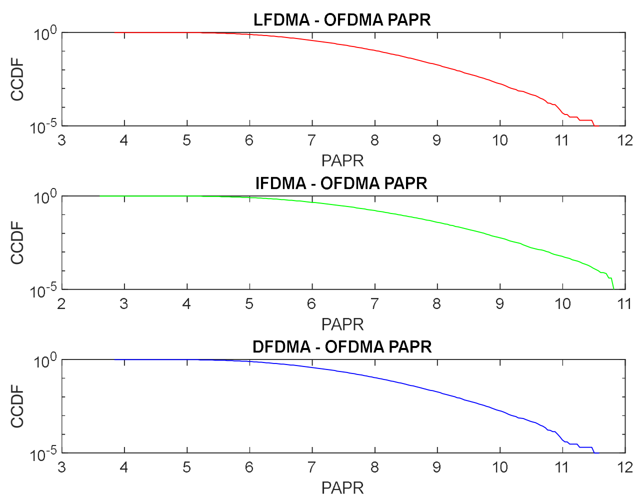

Figure 7. PAPR for OFDMA using LFDMA, IFDMA and DFDMA

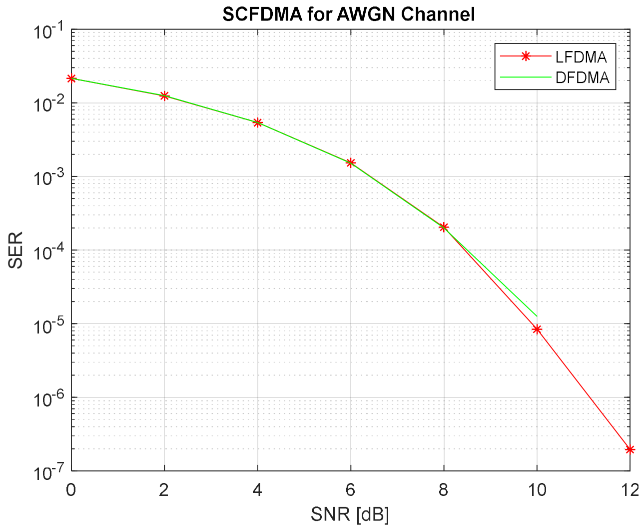

Figure 8. SNR vs SER : SC-FDMA

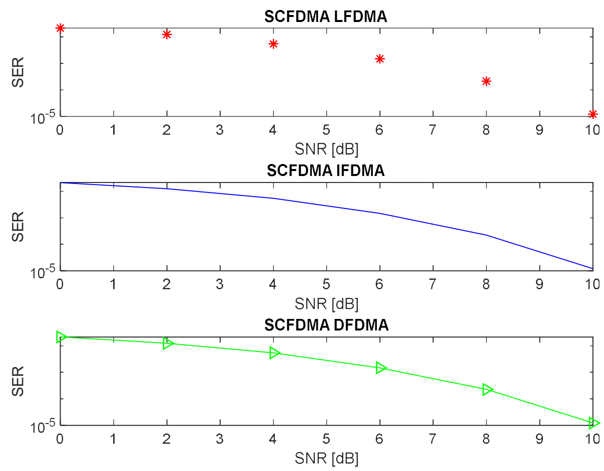

Figure 9. SNR vs SER of SC-FDMA for LFDMA, IFDMA and DFDMA

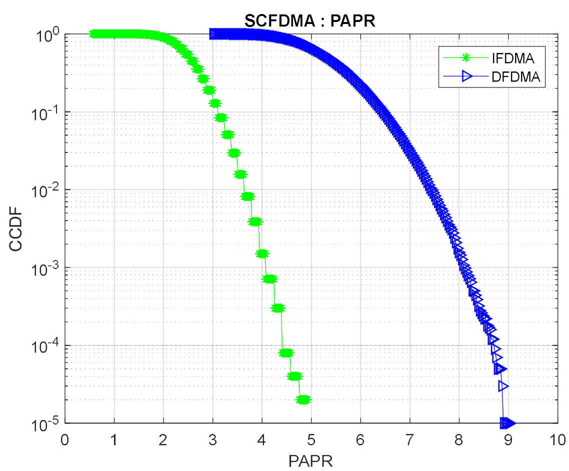

Figure 10 PAPR of SC-FDMA : IFDMA vs DFDMA

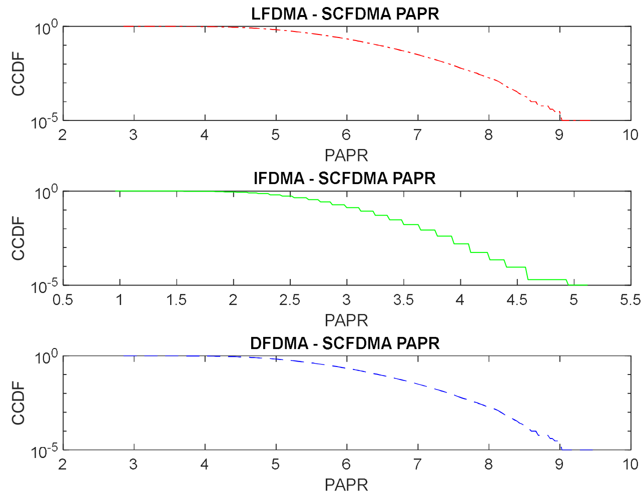

Figure 11. PAPR of LFDMA, IFDMA and DFDMA for SC-FDMA

5. CONCLUSIONS

This article focuses on the performance analysis of OFDMA and SC-FDMA systems based on their SER and PAPR. With the introduction of the AWGN channel, two types of FDMA subcarrier mapping were introduced: localised and distributed FDMA. There is a higher SER performance of LFDMA subcarrier mapping in comparison to those of IFDMA and DFDMA, which have less interference due to multiple access (MAI). In this study, we found that the PAPR performance of SC-FDMA was significantly better than that of OFDMA in the three subcarrier mapping techniques i.e. LFDMA, IFDMA, and DFDMA. The paper presented OFDMA and SC-FDMA systems. In comparison with OFDMA, the performance of SC-FDMA is superior.

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