Performance Analysis of SIMO-OFDM Wireless Communications Based on MRC Technique over AWGN and Frequency Selective Channels

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***Abstract*— The analysis of bit error rate (BER) performance of single input multiple output (SIMO) combined with orthogonal frequency division multiplexing (OFDM) wireless communication system exploiting maximum ratio combining (MRC) technique over additive white Gaussian noise (AWGN) and frequency selective channels are studied. SIMO system can be implemented by exploiting maximum ratio combiner (MRC) at the receiver side. MRC provides full spatial receive diversity gain which improves system quality of service (QoS) and as a result combatting a fading due to multipath propagation. Moreover, OFDM offers significant advantages such as bandwidth efficiency and its robustness against multipath delay spread. The level of robustness against the multipath delay spread can be further increased by selecting the length of the cyclic prefix (CP) more than or equal to channel length (CL) (number of multipaths). Adding CP eliminates or minimizes inter-symbol-interference (ISI). In contrast, when CL greater than CP leads to error floor at high SNR. This paper presents simulation BER performance of the combination of SIMO with OFDM systems. The simulation BER performance of conventional single input single-output (SISO-OFDM) one by one wireless system compared with SIMO-OFDM systems one by two, and, four receive antennas, with quadrature phase shift keying (QPSK) digital modulation scheme, over AWGN channel and frequency selective fading channel. The results confirm that the performance of SIMO-OFDM is significantly improved compared with conventional SISO-OFDM system. Moreover, the results also confirm that when CL greater than CP leads to error floor at high SNR. Furthermore, SIMO-OFDM (1Tx, 4Rx) improves BER performance significantly and mitigates ISI effectively.**

Keywords—SIMO system; OFDM system; ISI; AWGN channel; frequency selective channel

I. INTRODUCTION

The use of multiple antennas allows independent channels to be created in space which called diversity and is one of the most interesting and promising areas of recent innovation in wireless communications**.** Diversity is a technique in which multiple copies of the signal are created at the receiver. In the context of multiple input multiple output (MIMO), that have been developed to enhance the performance of wireless communication systems using multiple antennas at the receiver, transmitter, or both. MIMO techniques improve communications performance by either combating or exploiting multipath scattering in the communications channel between a transmitter and receiver. The first category of MIMO techniques exploits spatial diversity to combat multipath scattering in the communications channel. Whereas, the second category of MIMO techniques exploit multipath do so by performing spatial multiplexing [1]. The first category, spatial diversity can be exploited by using the single input multiple output (SIMO) technique. In another word, spatial diversity refers to techniques that are used to improve the reliability on a communications link by combating fading [2]. There are various ways to generate a diversity. First, frequency diversity is to transmit the signal on different RF frequencies that are spaced far enough apart that the fading occurs independently on each carrier. Second, time diversity, involves transmitting the same signal at different times slots. Third, polarization diversity is to transmit the same information on signals having different polarizations. Fourth, spatial transmit diversity, which refers to transmitting the same information over different independent paths between the multiple transmit antennas and one receive antenna. Fifth, spatial receive diversity is to transmit a signal from one transmit antenna and receive it using multiple receive antennas. This type of diversity will be the focus of this paper. Spatial receive diversity can be implemented by using SIMO, which is based on maximum ratio combiner (MRC) technique. The advantages of spatial receiver diversity are that it mitigates interference and the fluctuations due to fading so that the channel appears more like an AWGN channel [1], [3].

Orthogonal frequency division multiplexing (OFDM) is a broadband multicarrier modulation method that offers superior performance and benefits over traditional single-carrier modulation methods. OFDM scheme has the capability of converting a frequency selective channel into N parallel flat fading channels. OFDM is to split high rate radio channels into multiple lower rate subchannels that are then simultaneously transmitted over multiple orthogonal carrier frequencies [4]. OFDM is a modulation scheme that is suitable for high data rate transmission in frequency selective channel. It converts a high rate data stream into a N number of low rate streams that are transmitted over parallel flat fading channels which can be easily equalized. The input N symbols of QPSK mapped signals to inverse discrete Fourier transform (IDFT) are frequency domain components. These components are converted into time samples by performing an IDFT on these N symbols, which is efficiently implemented using the inverse fast Fourier transform (IFFT) algorithm. The IFFT algorithm produces the OFDM symbol consisting of the sequence $s[n] = s[0], \ldots, s[N-1]$ of length N as in (1). After

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the OFDM modulation, an OFDM symbol is generated and a cyclic prefix is added to combats the effects of ISI when communicating over the multipath frequency selective channel. The length of cyclic prefix is equal to the length of OFDM symbol divided by eight. If OFDM has 64 subcarriers, then, the length of cyclic prefix is eight (64/8=8). Therefore, the length of an OFDM symbol becomes 64 + 8 = 72 samples. Since the number of subcarriers is sufficiently high, it is assumed that each OFDM subcarrier experiences flat fading channel conditions in the frequency domain. Insertion of a cyclic prefix is essentially copying of the last part of the OFDM symbol to its beginning [5], [6] and [7].

$$s[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} S[k] e^{j2\pi nk/N}, \quad 0 \le n \le N-1, \tag{1}$$

where, $X[k]$ corresponds to samples of a sum of QPSK symbols, and $e^{j2\pi nk/N}$, $k = 0, \ldots, N\text{-}1$ is carrier frequency. Then, the reverse actions are taken at the receiver side. The demodulation steps of the OFDM receiver, use of the fast Fourier transform (FFT).

Combination of MIMO system with OFDM system has received much attention in recent years due to not only its high capacity, high QoS, high bandwidth efficiency and its robustness to multipath fading channels but also its reduction of ISI. Therefore, BER performance of SIMO-OFDM system will be studied in this work. Moreover, due to simple implementation of SIMO and OFDM systems. Therefore, this scheme has become the most popular and were incorporated into many communication standards, such as, IEEE 802.11n, long-term evolution (LTE), and LTE-Advanced as in [6] and [8]. There are several LTE transmission modes and the associated multiple antenna techniques as in [6]. Mode one uses spatial receive diversity. Whereas mode two is based on transmit diversity. Likewise, modes three and four are single-user implementations of spatial multiplexing based on open-loop and closed-loop precoding, respectively. The most important algorithm used in spatial receive diversity is known as MRC which is the focus of this work. It is used within mode one of transmission in the LTE standard, which is based on SISO mode where only one receiver antenna is deployed or SIMO mode where multiple receive antennas are used at the receiver side. In this model, LTE base stations usually have more than one received antenna whereas the mobile's test specifications assume that the mobile is using two receive antennas. So, LTE systems use receive diversity on the downlink as well as the uplink. Also, as in [1] and [4], IEEE 802.11n supports a wide variety of waveforms and antenna configurations, ranging from conventional SISO (1Tx, 1Rx) arrangements with no diversity to MIMO (M_tTx, M_rRx) configurations with various combinations of space time block coding (STBC) and spatial multiplexing. Likewise, IEEE 802.11n uses OFDM modulation to mitigate the effects due to frequency-selective fading channel.

A. The Focus of This Paper

Comparing BER performance of conventional SISO-OFDM (1Tx, 1Rx) system with SIMO-OFDM (1Tx, 2Rx, 4Rx) system over AWGN and frequency selective channels.

Furthermore, investigation of performance of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) system with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL = 8, 10, 12, 16, 20). Also, simple mathematical analysis of conventional SISO-OFDM and SIMO-OFDM are provided.

B. The Organization of the Rest of This Paper

The rest of this paper is organized as follows. In Section **II**, the SIMO-OFDM system over AWGN channel is presented. In addition, this section includes system models, mathematical models and simulation results of BER performance of SIMO-OFDM (1Tx, 1Rx, 2Rx, 4Rx) schemes. In Section **III**, the SIMO-OFDM system over frequency selective channel is studied. Likewise, this section includes system models and mathematical models. Moreover, simulation results of BER performance of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) schemes with different channel length are obtained. Finally, conclusions are given in Section **IV**.

C. The Common Notations Used in This Paper

Common notations that have been used in this paper are $(\cdot)^*$, $(.)^T$ and $(.)^H$ which denote complex conjugate, transpose and Hermitian transpose operations, respectively. $*$ and $\otimes$ are the discrete-time convolution and circular convolution, respectively.

Next, system model of SIMO-OFDM system over AWGN channel will be presented.

II. SIMO-OFDM (1Tx, 4Rx) Wireless System over AWGN Channel

A. System Model of SIMO-OFDM (1Tx, 4Rx) Wireless System over AWGN Channel

In the SIMO-OFDM (1Tx, 4Rx) system consists of one transmit antenna and four receive antennas and based on OFDM technique with 64 subcarriers par frame (N = 64). At the transmitter side, the input data stream is mapped by a QPSK mapping, resulting in a complex symbol stream $\boldsymbol{S[i]} = [S[0], \ldots, S[N-1]]$ where $i = 0, \ldots, N\text{-}1$. This discrete frequency symbol stream is passed through a serial-to-parallel (S/P) converter, whose output is a set of N parallel QPSK symbols $\boldsymbol{S[k]} = [S[0], \ldots, S[N-1]]^T$ corresponding to the symbols transmitted over each of the subcarriers. Then, these frequency components are converted into time samples by performing an inverse DFT on these N symbols, which is efficiently implemented using the IFFT algorithm. The IFFT yields the OFDM symbol consisting of the sequence $\boldsymbol{s[n]} = [s[0], \ldots, s[N-1]]^T$ of length N. Then, parallel-to-serial (P/S) converter is used. Hence, the signal sending from one transmit antenna through AWGN channel model. In this channel model, the channel coefficient is assumed to be one ($|h|^2$=1) because the wireless channel model is based on line-of-side (LOS) as in Figure 1. In this model, it is assumed, there is no multipath which means no ISI. So, as a result, cyclic prefix is not needed.

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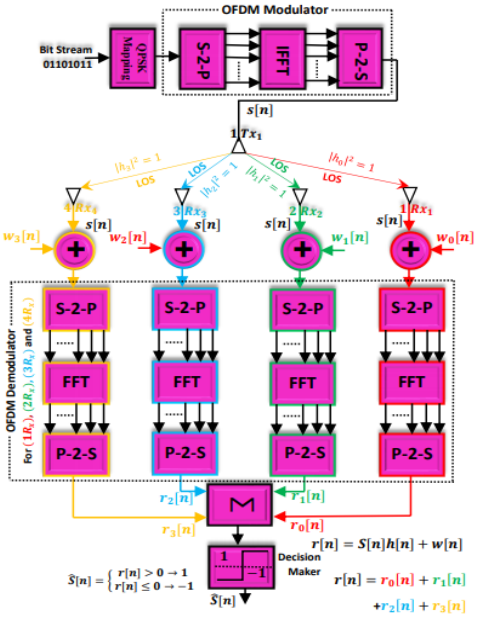

Fig. 1. Block diagram of SIMO-OFDM system (1Tx, 4Rx) over AWGN channel.

The receiver side consists of four receive antennas, each of which adds additive noise ($w_m[n]$) to received signal $r_m[n]$, m = 1, …, M_r (M_r = 4). Hence, serial-to-parallel (S/P) converted in each receive antenna. N time samples are passed through an FFT which resulting a received signal in frequency domain R_m[k], k = 0, . . ., N −1. The FFT output is parallel-to-serial (P/S) converted and passes through decision maker to estimate the QPSK received signal.

B. Mathematical Model of SIMO-OFDM (1Tx, 4Rx) Wireless System over AWGN Channel

The equations of received signals of SIMO-OFDM (1Tx, 4Rx) system with one transmit antenna and four receive antennas over AWGN channel. Each received signal is affected by just additive noise. Then, the equations can be written as:

$$r_1[n] = s[n] + w_1[n], \tag{2}$$
$$r_2[n] = s[n] + w_2[n], \tag{3}$$
$$r_3[n] = s[n] + w_3[n], \tag{4}$$
$$r_4[n] = s[n] + w_4[n]. \tag{5}$$

Then, the DFT outputs are frequency domain signals:

$$R_1[k] = S[k] + W_1[k],\ 0 \le k \le N-1, \tag{6}$$
$$R_2[k] = S[k] + W_2[k],\ 0 \le k \le N-1, \tag{7}$$
$$R_3[k] = S[k] + W_3[k],\ 0 \le k \le N-1, \tag{8}$$
$$R_4[k] = S[k] + W_4[k],\ 0 \le k \le N-1. \tag{9}$$

Then, the received signals are combined and the output equation of combiner can be expressed as following:

$$R[k] = R_1[k] + R_2[k] + R_3[k] + R_4[k]. \tag{10}$$

Then, the combined received signal passes through decision maker to estimate the received signal $\hat{S}[k]$ as following:

$$\hat{S}[k] = \begin{cases} R[k] > 0 \rightarrow 1 \\ R[k] \le 0 \rightarrow 0 \end{cases}. \tag{11}$$

C. Simulation Results of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 4Rx) Wireless System over AWGN Channel

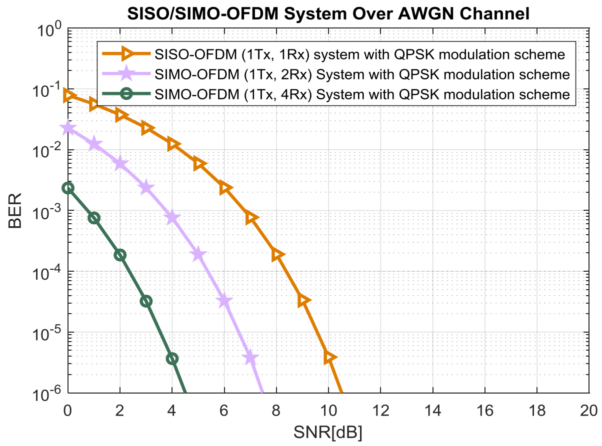

Fig. 2. Simulation results of BER performance of SISO-OFDM (1Tx, 1Rx), SIMO-OFDM (1Tx, 2Rx) and SIMO-OFDM (1Tx, 4Rx) systems with QPSK modulation scheme over AWGN Channel.

Figure 2 expresses the comparison of simulation results of QPSK modulation scheme BER performance of conventional SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) systems without cyclic prefix, over AWGN channel. In this model, each channel coefficients is assumed to be one ($|h|^2$=1) because this wireless channel model is based on LOS. Therefore, no ISI occur, as a result, no cyclic prefix is needed. It is clearly seen that the SISO-OFDM (1Tx, 1Rx) system has the worst BER performance, whereas, SIMO-OFDM (1Tx, 4Rx) system has the best BER performance. For example, to achieve 10^{-6} needs 11dB, 7.5dB and 4.5dB of systems SISO-OFDM (1Tx, 1Rx), SIMO-OFDM (1Tx, 2Rx) and SIMO-OFDM (1Tx, 4Rx), respectively.

System model of SIMO-OFDM system over selective channel will be studied next.

III. SIMO-OFDM (1Tx, 4Rx) Wireless System over Frequency Selective Channel

A. System Model of SIMO-OFDM (1Tx, 4Rx) Wireless System over Frequency Selective Channel

In the SIMO-OFDM (1Tx, 4Rx) system, the input data stream is mapped by a QPSK mapping, resulting in a complex symbol stream **S[i]** = [S[0], . . .,S[N−1]]. This discrete frequency symbol stream is passed through a serial-to-parallel converter, whose output is a set of N parallel QPSK symbols **S[k]** = [S[0], . . ., S[N−1]]^T corresponding to the symbols transmitted over each of the subcarriers. Then, these frequency components are converted into time samples by performing an inverse DFT on these N symbols, which is efficiently implemented using the IFFT algorithm. The IFFT yields the OFDM symbol consisting of the sequence **s[n]** = [s[0], . . . , s[N − 1]]^T of length N. The cyclic prefix is then added to the OFDM symbol, and the resulting time samples

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$\bar{\boldsymbol{s}}[\boldsymbol{n}] = \bar{s}[-L], \ldots, \bar{s}[N-1] = s[N-L], \ldots, s[0], \ldots, s[N-1]$ are ordered by the parallel-to-serial (P/S) converter. Then, the signal sending from one transmit antenna through frequency selective channel model. In this channel model, the channel coefficient is assumed to be vector $\boldsymbol{h}_{m,l} = [h_{m,1}\ h_{m,2} \ldots h_{m,L}]^T$, where, l = 1, 2,…, L is the channel length (CL) and m = 1, …, M_r (M_r = 4, is the number of receive antennas). This wireless channel model is based on multipath and non-line-of-side (NLOS) as in Figure 3. To eliminates or minimizes ISI, the length of the cyclic prefix (CP) should be mor than or equal the channel length (CL) (number of multipaths).

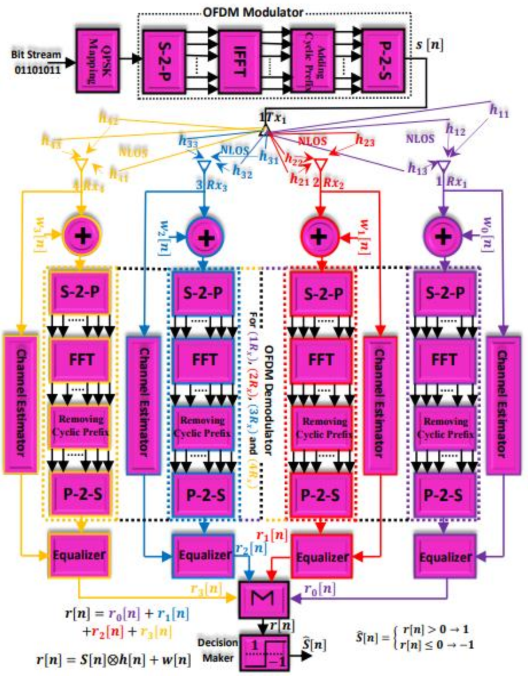

Fig. 3. Block diagram of SIMO-OFDM system (1Tx, 4Rx) over frequency selective channel.

The receiver side consists of four receive antennas, each of which adds additive noise ($w_m[n]$) to received signal $r_m[n]$, m = 1, …, M_r (M_r = 4). Hence, serial-to-parallel (S/P) converted in each receive antenna. The cyclic prefix consisting of the first μ samples is then removed from each receive signals $r_m[n]$. N time samples are passed through an FFT which resulting a received signal in frequency domain $R_m[k]$, $k = 0, \ldots, N-1$. The FFT output is parallel-to-serial (P/S) converted and passed through an equalizer. Equalizers remove the effect of flat fading on $S_m[k]$. Equalizers outputs combined and passes through decision maker to estimate the received signal. Then, passed through a QPSK de-mapper to recover the original data. In this work, it is assumed that the channel state information (CSI) is perfect known at the receiver.

B. Mathematical Model of SIMO-OFDM (1Tx, 4Rx) Wireless System over Frequency Selective Channel

The equations of received signals of SIMO-OFDM (1Tx, 4Rx) system with one transmit antenna and four receive antennas. Each received signal is affected by frequency selective channel and additive noise. Then, the equations can be written as:

$$r_1[n] = s[n] \otimes h_{1,l}[n] + w_1[n], \quad (12)$$
$$r_2[n] = s[n] \otimes h_{2,l}[n] + w_2[n], \quad (13)$$
$$r_3[n] = s[n] \otimes h_{3,l}[n] + w_3[n], \quad (14)$$
$$r_4[n] = s[n] \otimes h_{4,l}[n] + w_4[n]. \quad (15)$$

From DFT definition, the $DFT\{r[n]\} = R[k], 0 \leq k \leq N-1$, as a result, circular convolution in time domain leads to multiplication in frequency domain:

$$R_1[k] = S[k]H_1[k] + W_1[k], \quad 0 \leq k \leq N-1, \quad (16)$$
$$R_2[k] = S[k]H_2[k] + W_2[k], \quad 0 \leq k \leq N-1, \quad (17)$$
$$R_3[k] = S[k]H_3[k] + W_3[k], \quad 0 \leq k \leq N-1, \quad (18)$$
$$R_4[k] = S[k]H_4[k] + W_4[k], \quad 0 \leq k \leq N-1. \quad (19)$$

The demodulator can use the channel gains to estimate the received signal by using frequency equalization process as follows:

$$\tilde{R}_1[k] = R_1[k]/H_1[k], \quad (20)$$
$$\tilde{R}_2[k] = R_2[k]/H_2[k], \quad (21)$$
$$\tilde{R}_3[k] = R_3[k]/H_3[k], \quad (22)$$
$$\tilde{R}_4[k] = R_4[k]/H_4[k], \quad (23)$$

where $\tilde{R}_m[k]$, m = 1, …, M_r, (M_r = 4) are the equalized received signals, $R_m[k]$, are the received signals, and $H_m[k]$ are the channel transfer functions. Then, the combined received signals can be expressed as following:

$$\tilde{R}[k] = \tilde{R}_1[k] + \tilde{R}_2[k] + \tilde{R}_3[k] + \tilde{R}_4[k]. \quad (24)$$

Then, the combined received signal passes through decision maker to estimate the received signal $\hat{S}[k]$ as following:

$$\hat{S}[k] = \begin{cases} R[k] > 0 \rightarrow 1 \\ R[k] \leq 0 \rightarrow 0 \end{cases}. \quad (25)$$

C. Simulation Results of SISO-OFDM (1Tx, 1Rx) Wireless System over Frequency Selective Channel

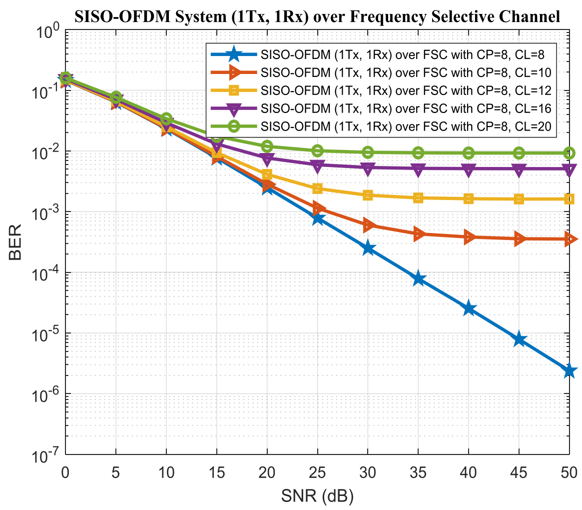

Fig. 4. Comparison of simulation results of QPSK-BER performance of SISO-OFDM (1Tx, 1Rx) system with cyclic prefix (CP=4), over frequency selective channel with different channel length (CL=1, 6, 8, 10, 16).

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Figure 4 illustrates comparison of simulation results of BER performance of SISO-OFDM (1Tx, 1Rx) system of QPSK modulation scheme with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL= 8, 10, 12, 16, 20). It is clearly seen that when channel length (CL) (number of multipaths signals) greater than cyclic prefix (CP) leads to inter-symbol-interference (ISI), which it is appear as flooring of the BER at certain level at high SNR. It is clear, from the figure, when the CL = CP = 8 there is no ISI appear. Whereas, when the CL = 10, 12, 16 and 20 the ISI appear and as consequence the BER floored at 4×10^{-4}, 2×10^{-3}, 5×10^{-4} and 10^{-2}, respectively. Finally, this figure confirms that, when the CL greater than CP leads to severe effect of ISI.

D. Simulation Results of SIMO-OFDM (1Tx, 2Rx) Wireless System over Frequency Selective Channel

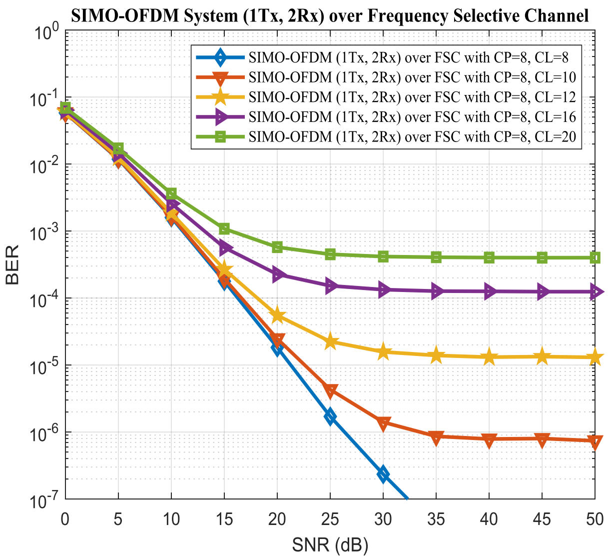

Fig. 5. Comparison of simulation results of QPSK-BER performance of SIMO-OFDM (1Tx, 2Rx) system with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL= 8, 10, 12, 16, 20).

Figure 5 shows comparison of BER performance of SIMO-OFDM (1Tx, 2Rx) system of QPSK modulation scheme with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL=8, 10, 12, 16, 20). It is clearly seen that when channel length (CL) (number of multipaths signals) greater than cyclic prefix (CP) leads to inter-symbol-interference (ISI), which it is appear as flooring of the BER at certain level at high SNR. For example, from the figure, when the CL = CP = 8 there is no ISI appear. Whereas, when the CL is greater than CP, the ISI is appeared, e.g. CL = 10, the ISI appear and as consequence the BER floored approximately at 10^{-6}. While the BER floored about at 10^{-5} when CL= 12. Moreover, CL= 16 leads to flooring of the BER at nearby 10^{-4} and CL= 20 leads to flooring of the BER at close 4×10^{-4}. Finally, this figure confirms that, SIMO-OFDM (1Tx, 2Rx) system has less effect of ISI compared with SISO-OFDM (1Tx, 1Rx) system.

E. Simulation Results of SIMO-OFDM (1Tx, 4Rx) Wireless System over Frequency Selective Channel

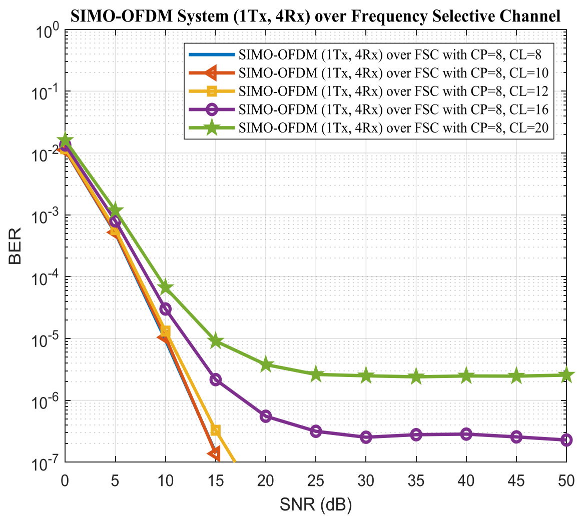

Fig. 6. Comparison of simulation results of QPSK-BER performance of SIMO-OFDM (1Tx, 4Rx) system with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL = 8, 10, 12, 16, 20).

Figure 6 demonstrates comparison of the BER performance of SIMO-OFDM (1Tx, 4Rx) system with cyclic prefix (CP = 8), over frequency selective channel with different channel length (CL = 8, 10, 12, 16, 20). It is clearly seen that when channel length (number of multipaths signals) less than or equal cyclic prefix, there is no ISI. However, from the figure, when the CL = CP = 8 there is no ISI appear. In addition, although the channel length greater than CP, still no ISI occurred, this due to great advantage of using multiple receive antennas. This is very clear from the figure when CP = 10 and 12, there is no ISI appeared. Whereas, when CL= 16 and 20, the BER floored at 2×10^{-6} BER reference and 3×10^{-7} BER reference, respectively. Finally, this result confirms that, even though, channel length (number of multipaths signals) is greater than cyclic prefix (CP) by exploiting four receive antennas the ISI is mitigated.

F. Compression of Simulation Results of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) Wireless Systems over Frequency Selective Channel with CP=8 and CL=20.

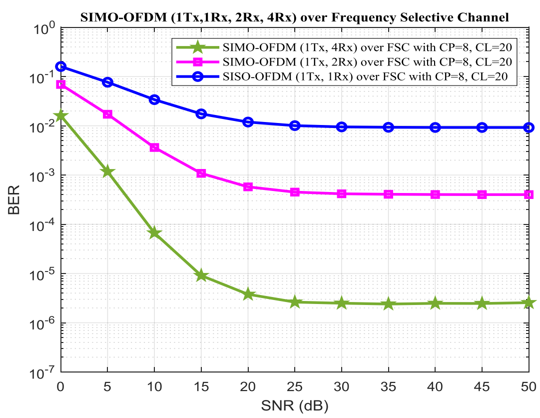

Fig. 7. Comparison of simulation results of QPSK-BER performance of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) systems, over frequency selective channel with cyclic prefix (CP = 8) and channel length (CL= 20).

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Figure 7 reveals comparison of the BER performance of conventional SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) systems with cyclic prefix (CP = 8), over frequency selective channel with channel length (CL = 20). From the figure, it is clear, due to ISI, the BER performance is floored at 2×10^{-6}, 10^{-4} and 10^{-2} BER reference of SIMO-OFDM (1Tx, 4Rx), SIMO-OFDM (1Tx, 4Rx) and SISO-OFDM (1Tx, 1Rx) systems, respectively. Consequently, it is clearly seen that SIMO-OFDM (1Tx, 4Rx) system has the best combating against ISI, whereas conventional SISO-OFDM (1Tx, 1Rx) system is the worst combating against ISI.

G. Compression of Simulation Results of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) Wireless Systems over Frequency Selective Channel with CP=8 and CL=12.

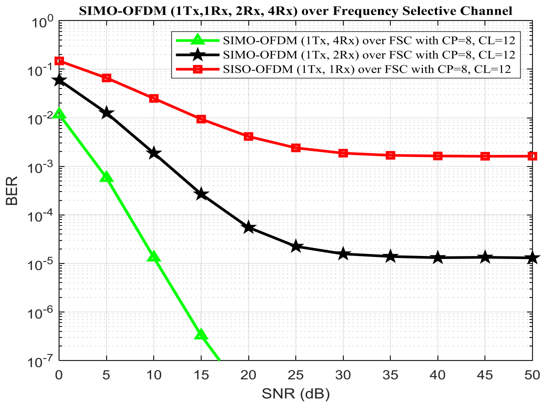

Fig. 8. Comparison of simulation results of QPSK-BER performance of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) systems, over frequency selective channel with cyclic prefix (CP = 8) and channel length (CL= 12).

Figure 8 states comparison of the BER performance of SISO-OFDM (1Tx, 1Rx) and SIMO-OFDM (1Tx, 2Rx, 4Rx) systems with cyclic prefix (CP = 8), over frequency selective channel with channel length (CL = 12). Although, channel length (CL) (number of multipaths signals) greater than cyclic prefix (CP), the BER performance is floored at 2×10^{-3}, 10^{-5} and non-floored, of SISO-OFDM (1Tx, 1Rx), SIMO-OFDM (1Tx, 2Rx) and SIMO-OFDM (1Tx, 4Rx) systems, respectively. As a result, it can be concluded that SIMO-OFDM (1Tx, 4Rx) system is very effective to combating ISI, whereas conventional SISO-OFDM (1Tx, 1Rx) system is very poor at combating ISI.

IV. Conclusions

In this paper, we have studied a simulation of BER performance of SISO-OFDM and SIMO-OFDM wireless communication system consists of two, and four receive antennas, based on MRC technique, over AWGN and frequency selective channels. The results confirmed that, generally, when channel length (CL) (number of multipaths signals) greater than cyclic prefix (CP) leads to inter-symbol-interference (ISI), which it is appear as flooring of the BER at certain level at high SNR. Furthermore, SIMO-OFDM (1Tx, 4Rx) system has had the best combating against ISI, whereas conventional SISO-OFDM (1Tx, 1Rx) system was the worst at combating against ISI. Moreover, although, the number of multipaths in communication channel is greater than the cyclic prefix, by exploiting four receive antennas the ISI was effectively mitigated. An analysis of BER performance of cooperative MIMO-OFDM system will be a subject of our ongoing study.

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