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Single Carrier Frequency Domain Equalization

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ABSTRACT

As the demand of wireless services is rising, there is a need to transmit high-speed packets over the wireless communication channel. Broadband data transmission over wireless channels commonly faces the challenges of multipath fading channels, which are both time and frequency selective. Orthogonal frequency division multiplexing (OFDM) has become widely accepted as transmission technique primarily because of its robustness against frequency selective fading channels, but it suffers a number of drawbacks such as high peak-to-average power ratio (PAPR), intolerance to amplifier nonlinearities, and high sensitivity to carrier frequency offsets (CFOs). SINGLE CARRIER Frequency Domain Equalization (SCFDE) is an alternative to OFDM that avoids OFDM drawbacks. Single carrier with frequency domain equalization (SCFDE) transmission utilizes single carrier modulation at the transmitter, and it performs frequency domain equalization at the receiver. SC-FDE is a technique in which, similar to OFDM, equalization is performed in the frequency domain, but has the advantage of having lower PAPR. This is important especially in the uplink communications, where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency and manufacturing cost. In SC-FDE, Equalization is done for single carrier transmission by inserting cyclic-prefix (CP) in the transmitter and Multiplying by a single equalization tap in the frequency domain at the receiver. The objective of this work is to design a single carrier frequency domain equalization systems using space time block code and receiver diversity which provides a satisfactory performance under slow fading environment.

INTRODUCTION

Wireless mobile communication techniques are rapidly moving toward fourth generation. There is huge demand of high speed services. The main goal of upcoming generation systems are higher bit rate, higher spectrum efficiency in addition to conventional speech transmission as in previous generation systems.

The transmission rate achieved by second generation systems was within range of 9.6 kbps-28.8 kbps. While the transmission rate achieved by third generation systems was 2Mbps for stationary user and 348 kbps for moving user. The transmission rate requirement of third generation partnership project-long term evolution system is still higher and it is 100Mbps downlink with spectral efficiency of 5bps. [13].

Multiple inputs multiple outputs provide either multiplexing gain or diversity gain. Multiplexing gain provides increase in data rate while diversity gain provides reliability in fading environment. Space time block coding is one of the transmitter diversity techniques [13]. Space time block coding at the transmitter side provides reliability in slow fading channel environment. Maximum ratio receiver combining technique also provides reliability in slow fading channel environment.

Single Carrier Frequency Domain Equalization

Single carrier frequency domain equalization system is used in third generation partnership project long term evolution and upcoming generation mobile communication. Orthogonal frequency division multiplexing (OFDM) has been recently adopted by major manufacturers and by standardization bodies for a wide range of wireless and wire line applications ranging from digital video/audio broadcasting to power-line communications. The major virtues of OFDM are

(1) It's resilience to multipath propagation providing a viable low-complexity and optimal (in maximum likelihood sense) solution for inter symbol interference (ISI) mitigation. 2

(2)The possibility of achieving channel capacity if the transmitted signal is adapted to the state of the communication channel.

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(3) The availability of strategies for frequency diversity scheduling in multiuser communication systems. Although OFDM has become the physical layer of choice for broadband communications Standards, it suffers from several drawbacks including a large peak-to-average power ratio (PAPR), intolerance to amplifier nonlinearities and high sensitivity to carrier frequency offsets (CFOs) [6]. This is due to reason that in orthogonal frequency division multiple access systems transmission of user data symbols is on different narrow band subcarrier in parallel but in single carrier frequency domain equalization system transmission of user data symbols is on one carrier serially. hence need of sending frequency offset information in single carrier frequency domain equalization systems is less as compared to that of need of sending frequency offset information in orthogonal frequency division multiple access system [1].

One another advantage of single carrier frequency domain equalization system is lower peak to average power ratio. Single carrier frequency domain equalization technique has lower peak to average power ratio as compared to that of orthogonal frequency division multiple access [1]. The peak to average power ratio is not a big issue for base station as there is unlimited availability of power supply hence in third generation partnership project-long term evolution orthogonal frequency division multiplexing is used for forward link (downlink) communication that is from base station to mobile terminals. But peak to average power ratio create more challenges to the instrument running on external limited power supplied batteries. For the system with high peak to average power ratio such as multicarrier system like orthogonal frequency division multiple access there is need to design extremely linear power amplifier.

DESIGN OF 2X1 (Tx-Rx) SCFDE SYSTEM USING STBC

Design of single carrier frequency domain equalization system using space time block codes and receiver diversity for 2 transmit antenna and 1 receive antenna is as follows.The block diagram of transmitter of 2x1 (Tx-Rx) SCFDE system is shown in figure ,the symbol notification of SCFDE system is given in Figure, the block diagram of 2x1 (Tx-Rx) SCFDE system is shown in figure, and the block diagram of receiver of 2x1 (Tx-Rx) SCFDE system is shown in figure

Transmitter Structure using STBC

1. Let the input bit stream be *b0, b1,…bM-1* bit stream is encoded by a channel encoder such as convolution or turbo encoder.
2. One of the following modulation schemes (BPSK/QPSK) is used to modulate the encoded stream.
3. Modulated symbols are collected into group of M and then converted serial to parallel using serial to parallel converter.

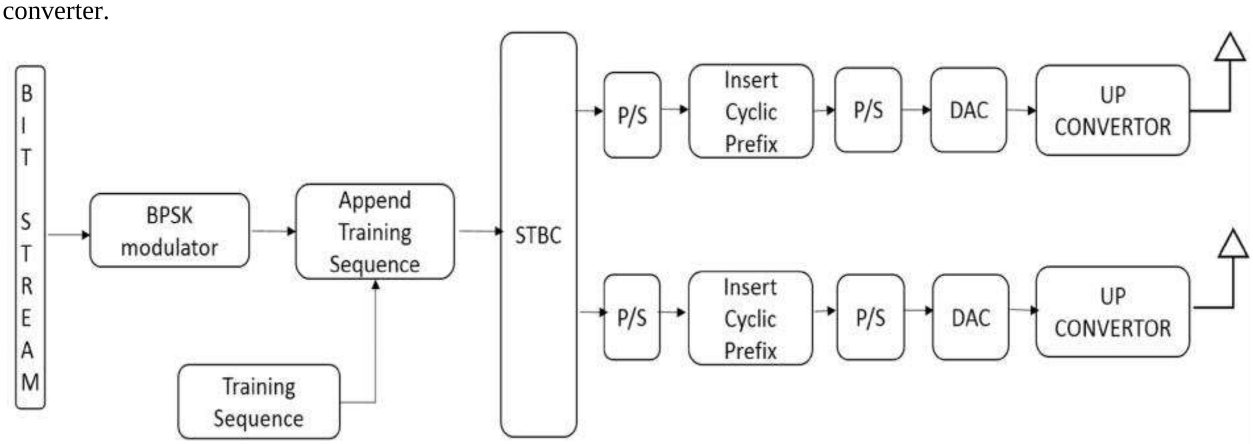

Figure-1 Block diagram for transmitter of 2x1(Tx-Rx) system

Resulting time domain complex signals are parallel to serially converted and then cyclic prefix is inserted then digital to analogue conversion take place and at last up-conversion occurs and then transmitted through antenna 1 and antenna 2.

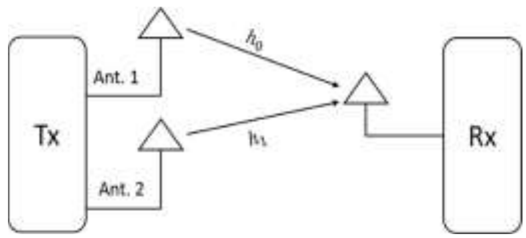

Figure 2 2x1 (Tx-Rx) system

Reciver

1. The transmitted signal gets attenuated through the channel. There is additive white Gaussian noise consideration. At the receiver received signals are down converted and there is analogue to digital conversion requirement.
Let = [, , ……….] be the signal received at antenna 1 in time domain after down–converting is given in 3.7 equation and passing through an analogue to digital convertor and = […………. .] be the samples of the additive white Gaussian nose at
antenna1.

$$=h + h\ 1 + ,\ 0 \leq k \leq N-1 \quad (3.3)$$

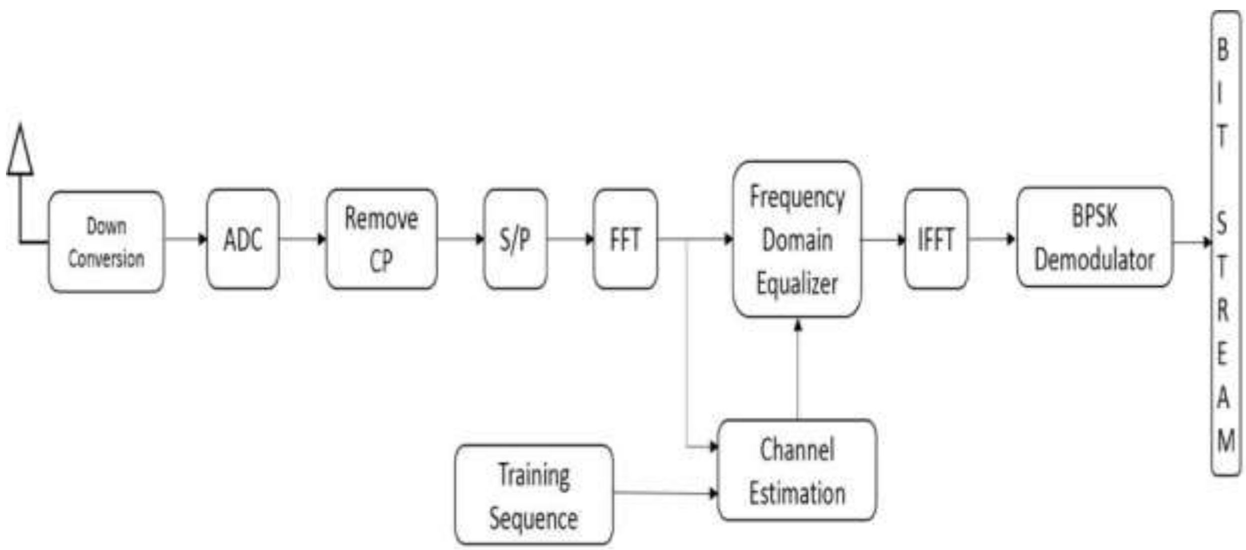

Figure-3 Block diagram for receiver of 2x1(Tx-Rx) system

DESIGN OF 1X2 (TX-RX) SCFDE SYSTEM USING RECEIVER DIVERSITY

Design of single carrier frequency domain equalization system using receiver diversity for transmit antenna and 2 receiver antenna is as follows. The block diagram of transmitter of 1x2 (Tx-Rx) SCFDE system is shown in figure ,the symbol notification of 1x2 (Tx-Rx) SCFDE system is shown in figure , the block diagram of 1x2 (Tx-Rx) SCFDE system is shown in figure 4.3 and the block diagram of receiver of 1x2 (Tx-Rx) SCFDE system is shown in figure .The transmitter block diagram of 1 transmitter 2 receiver single carrier frequency domain equalization system using receiver diversity is as follows:

TRANSMITTER

1. Let the input bit stream be *b0, b1,…bM-1* bit stream is encoded by a channel encoder such as convolution or turbo encoder.
2. One of the following modulation schemes (BPSK/QPSK) is used to modulate the encoded stream.

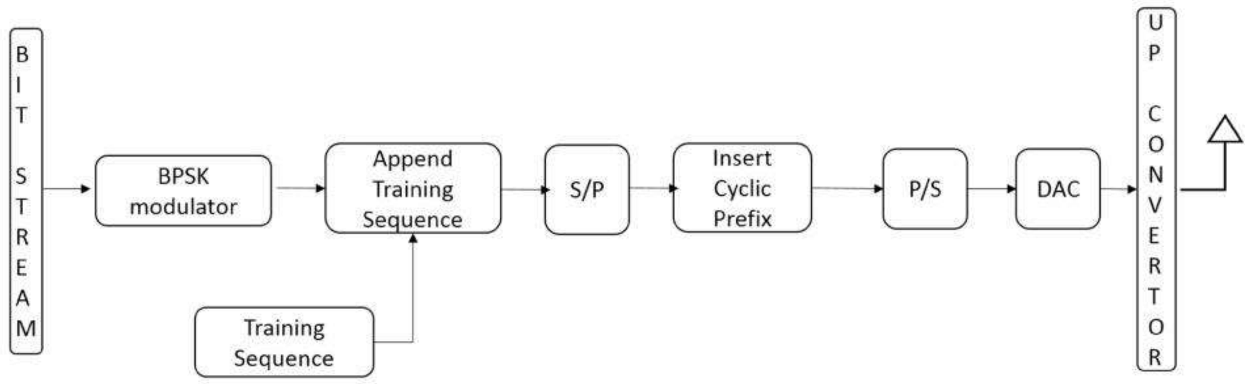

Figure-4 Block diagram for transmitter of 1x2 (Tx-Rx) system

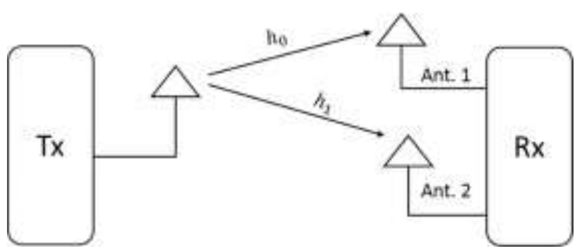

Figure 5 1x2 (Tx-Rx) system

DESIGN OF 2X2 (Tx-Rx) SCFDE SYSTEM USING STBC AND RECEIVER DIVERSITY

Design of single carrier frequency domain equalization system using space time block codes and receiver diversity for 2 transmit antenna and 2 receive antenna is as follows. The block diagram of transmitter of 2x2 (Tx-Rx) SCFDE system is shown in figure , the symbol notification of SCFDE system is given in Figure, the block diagram of 2x2 (Tx-Rx) SCFDE system is shown in figure , and the block diagram of receiver of 2x2 (Tx-Rx) SCFDE system is shown in figure .

Transmitter Structure using STBC

1. Let the input bit stream be *b0, b1,…bM-1* bit stream is encoded by a channel encoder such as convolution or turbo encoder.
2. One of the following modulation schemes (BPSK/QPSK) is used to modulate the encoded stream.
3. Modulated symbols are collected into group of M and then converted serial to parallel using serial to parallel converter.

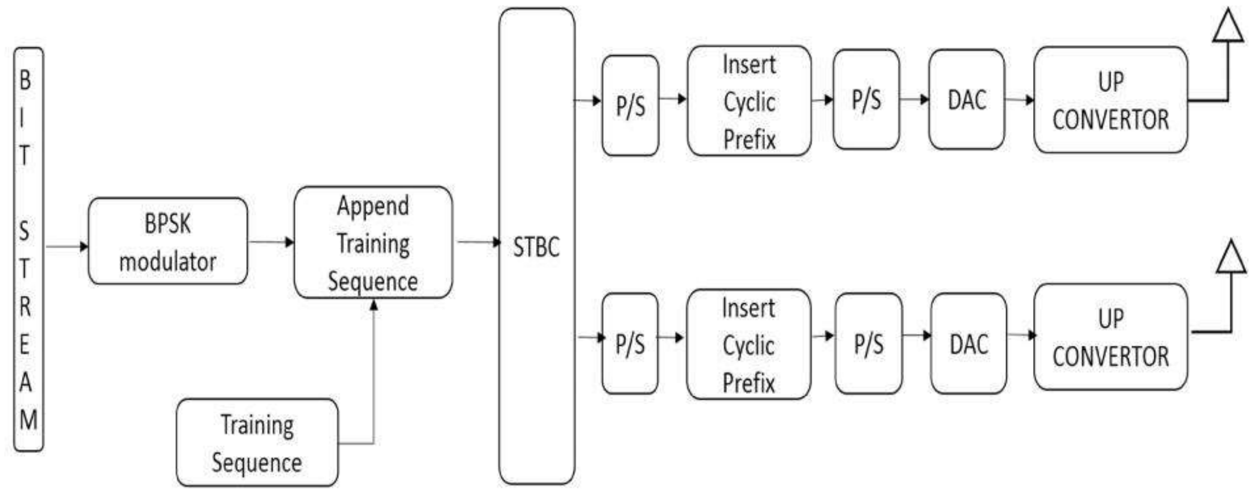

Figure- 6 Block diagram for transmitter of 2x2(Tx-Rx) system

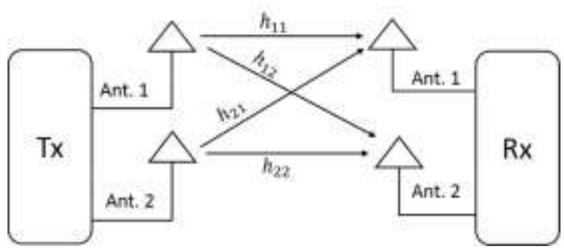

Figure 7 2x2 (Tx-Rx) system

SIMULATION RESULT AND DISCUSSION

Simulation Parameters

Transmitter	**Modulation**	**BPSK**
	Cyclic Prefix	**100**
Channel	**Channel Model**	**UWB (IEEE 802.15.3a)(CM1, CM2, CM3, CM4)**
		Multipath Slow fading
	Noise Environment	**AWGN**
Receiver	**FFT Size**	**512**
	Equalizer	**ZF, MMSE, (Frequency Domain Equalizer)**
	Channel Estimation	**Using Training Sequence**

Discussion

In order to Analyze BER performance, SC-FDE system is implemented using above mentioned parameters. We have taken the UWB channel model (IEEE 802.15.3a). For MIMO and MISO system STBC code is used to achieve transmit diversity. We have assumed channel to be static for one STBC block. Simulation results are shown as follow:

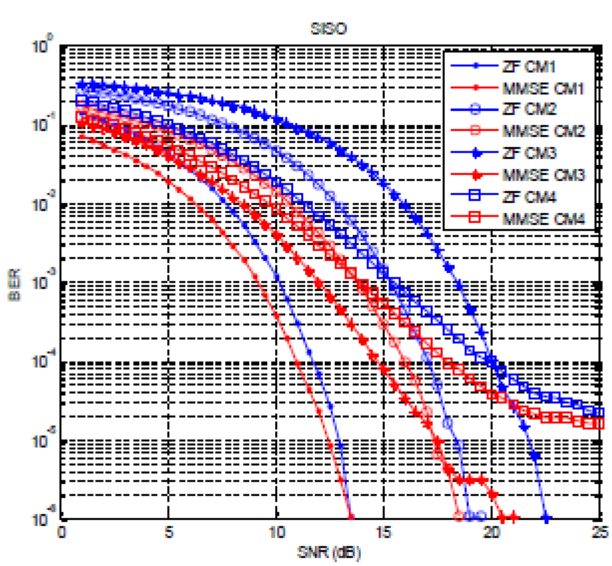

Figure 8 performances of ZF and MMSE

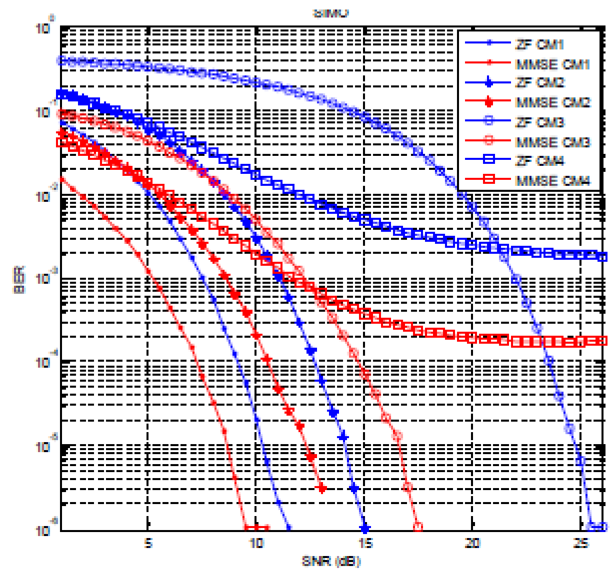

Figure 9 BER of SIMO SC-FDE

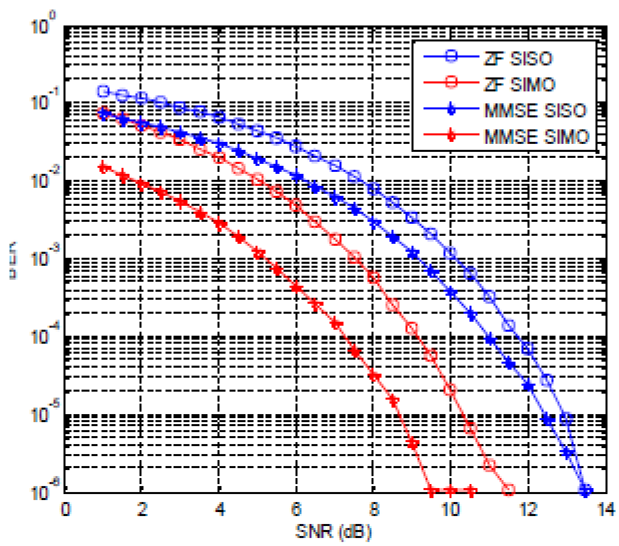

Figure 10 comparative analysis is shown between SISO and SIMO systems under CM1 UWB channel model.

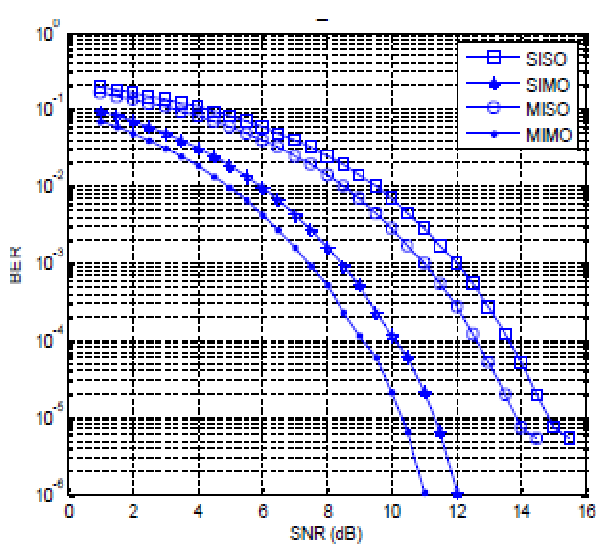

Figure 11 BER performances of SISO, SIMO, MISO and MIMO SC-FDE

In Fig. 8 performances of ZF and MMSE is analyzed in all channel environments (CM1, CM2, CM3, CM4). The number of multipath is chosen to gather more than 99% of channel energy (64 for CM1, 64 for CM2, 100 for CM3, 120 for CM4). Simulation result shows that BER of the SCFDE system tends to zero at high SNR for CM1, CM2, CM3. Performance is as far as number of multipath is less than the length of cyclic prefix**.** In all Channel environments MMSE shows better performance as compared to ZF at low SNR which is as expected.

In fig. 9, BER of SIMO SC-FDE is plotted under all channel environments. In the simulation we have considered 1 Transmitting antenna and 2 receiving antennas. We used MRRC (MaximumRatio Receiver Combining) for combing received signals.

In Fig 10, A comparative analysis is shown between SISO and SIMO systems under CM1 UWB channel model. The BER performance of SIMO is better than SISO due to increase in receiver diversity.

In Fig 11, Comparative BER performances of SISO, SIMO, MISO, MIMO SC-FDE are shown using ZF equalizer. For implementing MISO and MIMO we considered 2 transmitting antennas with Space Time Block Code (STBC). BER performance of MIMO comes out to be better than all other due to both transmitter and receiver diversity.

CONCLUSION

The 2x2 (Tx-Rx) single carrier frequency domain equalization system using space time block coding and receiver diversity has the best performance in terms of BER (Bit Error Rate). While the 2x1 (Tx-Rx) single carrier frequency domain equalization system using space time block coding has better performance than 1x2 (Tx-Rx) and 1x1 (Tx-Rx) single carrier frequency domain equalization system in terms of BER. And the 1x2 (Tx-Rx) single carrier frequency domain equalization system using receiver diversity has better performance than 1x1 (Tx-Rx) single carrier frequency domain equalization system in terms of BER. For UWB channel (slow fading), the 2x2 (Tx-Rx) single carrier frequency domain equalization system using space time block code and receiver diversity and 2x1 (Tx-Rx) single carrier frequency domain equalization system using space time block coding have nearly similar performance but lesser BER than other two systems 1x2 (Tx-Rx) and 1x1 (Tx-Rx) single carrier frequency domain equalization system. While 1x2 (Tx-Rx) single carrier frequency domain equalization system using receiver diversity and 1x1 (Tx-Rx) single carrier frequency domain equalization systems have similar performance.

REFERENCES

1. A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2006.
2. J. G. Proakis, *Digital Communications*, 4th Ed. New York, McGraw- Hill, Inc., 2001.
3. T. S. Rappaport, *Wireless Communications: Principles and Practice*, Englewood Cliffs, NJ: Prentice Hall, 1996.
4. Steven M. Kay, Ed., Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory.
5. Siavash M Alamouti, "A simple transmit diversity technique for wireless communications," Selected Areas in Communications, IEEE Journal on, vol. 16, no. 8, pp. 1451-1458, 1998.
6. David D. Falconer, S. Lek Ariyavisitakul, "Broadband Wireless Using Single Carrier and Frequency Domain Equal izat ion" IEEE Conference,pp. 27-36, 2002.
7. Yeesoo Han , Heon Huh and James V. Krogmeier," Comparison of Error Probability for OFDM and SCFDE" IEEE Conference, pp. 497-501, 2003.
8. Yue Wang and Xiaodai Dong, "Performance of SC-FDE System in UWB Communications with Imperfect Channel Estimation", Journal Of Communications And Networks, Vol. 9, No. 4, pp. 466-472, 2007.
9. Valentin GHEORGHIU, Fumiyuki ADACHI, "Implementation of Frequency Domain Equalizer for Single Carrier Transmission", IEEE Conference, pp. 1-5, 2008.
10. Ahmed Hesham Mehana and Aria Nosratinia, "Performance of MIMO Single-Carrier Frequency Domain Zero-Forcing Equalizer", IEEE International Symposium on Information Theory Proceedings, pp. 3023-3027, 2012.
11. Neng Bai, Guifang Li, "Adaptive frequency domain equalization for mode-division multiplexed transmission", IEEE Conference, pp. 185-186, 2012.
12. Mario Marques da Silva 1,2,3, Rui Dinis 1,4, Paulo Montezuma, "Iterative FDE Receivers for UWB Systems with Strong Interference Levels", IEEE Conference, pp. 1-6, 2013.
13. S. Reinhardt, T. Buzid, M. Heumer, \Receiver structures for MIMOSC/FDE Systems," IEEE 63rd Vehicular Technology Conference, vol-6, pp.1401-1405, May 2006. 41
14. S. Reinhardt, T. Buzid, M. Heumer, \Receiver structures for MIMOSC/ FDE Sys tems," IEEE 63rd Vehicular Technology Conference, vol-6, pp.1401-1405, May 2006.

15. M. V. Clark, \Adaptive Frequency-Domain Equalization and Diversity Combining for Broadband Wireless Communications," IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 16, NO. 8, pp.1285-1395, Oct 1998.
16. K. A. Ch. Sridevi, \IMPLEMENTATION OF MMSE EQUALIZER USING VARI ANTS OF LMS," IJERT Volume 1, Issue 7, April 2012.
17. S. A. DD. Falconer, \Broadband Wireless Using Single Carrier and Frequency Domain Equalization," IEEE Wireless Personal Multimedia Communications, vol. 1, pp.27-36, Oct 2002.