International Journal of Electrical, Electronics and Computer Engineering **3**(1): 142-145(2014)

ISSN No. (Online): 2277-2626

Multi channel Transmission over the space-time-frequency Multi path & Multiband-OfDM Based Ultra-Wideband MIMO Communication System

Rahul Baghel, Bhaskar Singh and Pushpraj Singh Tanwar
Department of Electronic and Communication Engineering,
RITS, Bhopal, (MP), India

(Corresponding author Rahul Baghel)
(Received 05 February, 2014 Accepted 15March, 2014)

ABSTRACT: The emerging ultra wideband (UWB) system offers a great potential for the design of high speed short-range wireless communications. In order to satisfy the growing demand for higher data rates, one possible solution is to exploit both spatial and multi path diversities via the use of multiple-input multiple-output (MIMO) and proper coding techniques. In this paper, we propose a general framework to analyze the performance of multi band UWB-MIMO systems regardless of specific coding schemes. A combination of space-time-frequency (STF) coding and hopping multi band OFDM modulation is also proposed to fully exploit all of the available spatial and frequency diversities, richly inherent in UWB environments. We quantify the performance merits of the proposed scheme in case of Nakagami- frequency-selective fading channels. Different from the conventional STF coded MIMO-OFDM system, the performance of the STF coded hopping multi band UWB does not depend on the temporal correlation of the propagation channel. We show that the maximum achievable diversity of multi band UWB-MIMO system is the product of the number of transmit and receive antennas, the number of multi path components, and the number of jointly encoded OFDM symbols. Interestingly, the diversity gain does not severely depend on the fading parameter, and the diversity advantage obtained under Nakagami fading with arbitrary parameter is almost the same as that obtained in Rayleigh fading channels. Finally, simulation results are presented to support the theoretical analysis.

Keywords: Frequency selective fading channels, multi band orthogonal frequency-division multiplexing (OFDM), multiple antennas, ultra wideband (UWB), wireless

I. INTRODUCTION

The major challenges in future wireless communications system design are increased spectral efficiency and improved link reliability. The wireless channel constitutes a hostile propagation medium, which suers from fading (caused by destructive addition of multipath components) and interference from other users. Diversity provides the receiver with several (ideally independent) replicas of the transmitted signal and is therefore a powerful means to combat fading and interference and thereby improve link reliability. Common forms of diversity are time diversity (due to Doppler spread) and frequency diversity (due to delay spread). In recent years the use of spatial (or antenna) diversity has become very popular, which is mostly due to the fact that it can be provided without loss in spectral efficiency. Receive diversity, that is, the use of multiple antennas on the receive side of a wireless link, is a well-studied subject [1]. Driven by mobile wireless applications, where it is difficult to deploy multiple antennas in the handset.

The use of multiple antennas on the transmit side combined with signal processing and coding has become known under the name of space-time coding [2, 4] and is currently an active area of research. The use of multiple antennas at both ends of a wireless link (multiple-input multiple-output (MIMO) technology) has recently been demonstrated to have the potential of achieving extraordinary data rates [5{9]. The corresponding technology is known as spatial multiplexing [5,9] or BLAST [6,10] and yields an impressive increase in spectral efficiency. Most of the previous work in the area of MIMO wireless has been restricted to narrowband systems. Besides spatial diversity broadband MIMO channels, however, over higher capacity and frequency diversity due to delay spread. Orthogonal frequency division multiplexing (OFDM) [11,12] significantly reduces receiver complexity in wireless broadband systems. The use of MIMO technology in combination with OFDM, i.e., MIMO-OFDM [8,9,13], therefore seems to be an attractive solution for future broadband wireless systems.

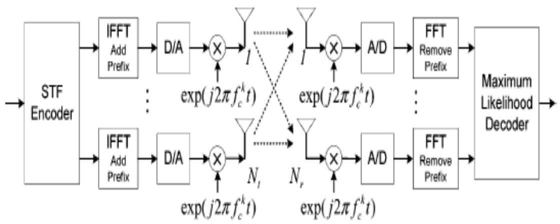

Fig. 1. Multi band UWB-MIMO system.

ULTRAWIDEBAND (UWB) is an emerging technology that offers great promises to satisfy the growing demand for low cost and high-speed digital wireless home networks.

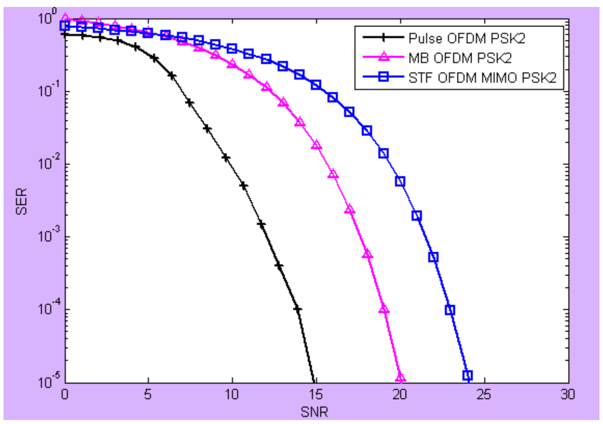

Fig. 2. Pulse ofdm psk2 SNR 15 db,M B ofdm psk2 SNR 20 db,STF ofdm MIMO Psk2 SNR 24 db.

UWB is defined as any radio transmission that occupies a bandwidth of more than 20% of its center frequency, or nominally more than 500 MHz. In 1998, the Federal Communications Commission (FCC) has mandated that UWB radio transmission can legally operate in the range from 3.1 GHz to 10.6 GHz, at a transmit power of dBm/MHz [1]. Depending on how the available bandwidth is utilized, UWB can be divided into two groups: single band and multi band. A traditional UWB technology is based on single-band systems employing carrier-free communications [2]–[6].

It is implemented by directly modulating information into a sequence of impulse-like waveforms, which occupy the available bandwidth of 7.5 GHz. Multiple users can be supported via the use of time hopping or direct sequence spreading approaches. The single band system faces a challenging problem in building RF and analog circuits, and in designing a low complexity receiver that can capture sufficient multi path energy.

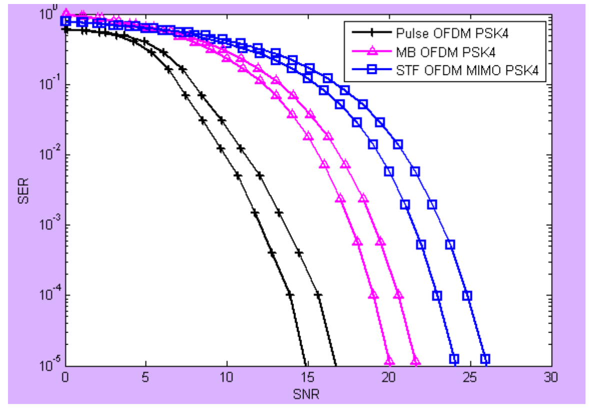

Fig. 3. Pulse ofdm psk4 SNR 16 db,M B ofdm psk4 SNR 22 db,STF ofdm MIMO Psk4 SNR 26 db.

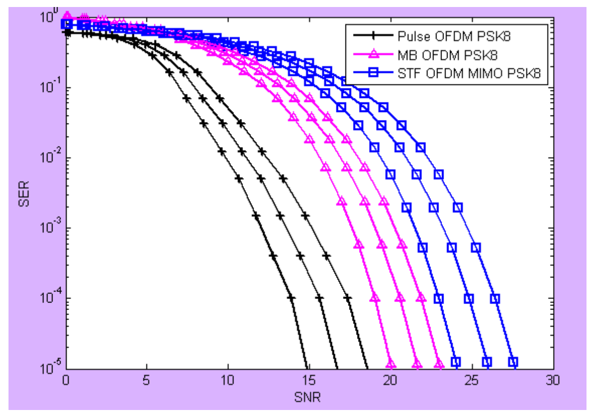

Fig. 4. Pulse ofdm psk8 SNR 18 db,M B ofdm psk8 SNR 23 db,STF ofdm MIMO Psk8 SNR 27 db.

Recently, multi band UWB schemes were proposed in [7]–[9], in which the UWB frequency band is divided into several sub bands. Each sub band occupies a bandwidth of at least 500 MHz in compliance with the FCC regulations. [19] By interleaving the symbols across sub bands, multi band UWB can maintain the transmit power as if the large GHz bandwidth is utilized. The advantage is that multi band approach allows the information to be processed over a much smaller bandwidth, thereby reducing overall design complexity as well as improving spectral flexibility and worldwide compliance. To efficiently capture the multi path energy, orthogonal frequency division multiplexing (OFDM) technique has been used to modulate the information in each subband. The major difference between multi band OFDM and traditional OFDM schemes is that the multi band OFDM symbols are not continually sent on one frequency-band; instead, they are interleaved over different sub bands across both time and frequency.

Multiple access of multi band UWB is enabled by the use of suitably designed frequency-hopping sequences over the set of sub bands. Currently, UWB technology achieves data rates ranging from 55 to 480 Mbits/s over distances up to 10 m. To enhance the data rates and the coverage ranges, the employment of multiple-input multiple-output (MIMO) scheme to UWB has gained considerable interest recently. In conventional RF technology, MIMO has been well known for its effectiveness of improving system performance in fading environments.

Space-time (ST) coded MIMO systems [12]–[14] have been proposed for narrowband communications, where the fading channel is frequency-nonselective.

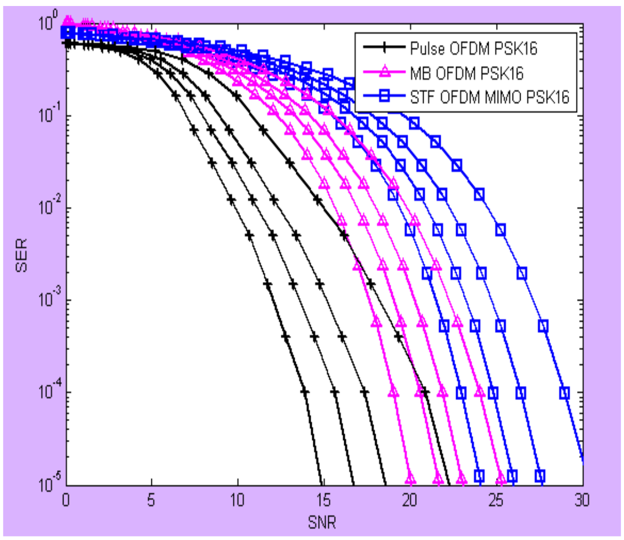

Fig. 5. Pulse ofdm psk16 SNR 19 db,M B ofdm psk16 SNR 25 db,STF ofdm MIMO Psk16 SNR 30 db.

The main concept is the joint processing in time as well as in space via the use of multiple transmit and receive antennas, so as to achieve both Consider a multi band OFDM scenario that has been proposed in the IEEE 802.15.3a WPAN standard [20]. The available UWB spectrum of 7.5 GHz is divided into several sub bands, each with bandwidth BW of at least 500 MHz. Each user utilizes one sub band per transmission. For each user, signals from all transmit antennas share the same sub band. Within each subband, OFDM modulation with sub carriers is used at each transmit antenna. Different bit rates are achieved by using different channel coding, frequency spreading, or time spreading rates.

We consider a multi band UWB system with fast band-hopping rate, i.e., the signal is transmitted on a frequency-band during one OFDM symbol interval, and

then moved to a different frequency band at the next interval.

CONCLUSION

In conventional OFDM systems with transmit and receive antennas, STF coding across OFDM blocks can lead to a maximum achievable diversity order of , where is the number of resolvable paths and is the rank of the temporal correlation matrix of the channel . In this paper, we proposed a multi band MIMO coding framework for UWB systems. By a technique of band hopping in combination with jointly coding across spatial, temporal and frequency domains, the proposed scheme is able to exploit all available spatial and multi path diversities, richly inherent in UWB environments. From the theoretical results, we can draw some interesting conclusions as follows. First, the effect of Nakagami fading parameter on the diversity gain is insignificant, and the diversity advantages obtained in Nakagami- fading and Rayleigh fading channels are almost the same. Second, the maximum achievable diversity advantage of multi band UWB-MIMO system is . In contrast to the conventional OFDM, the factor comes from the band hopping approach, which is regardless of the temporal correlation of the channel. The simulation results showed that the employment of STF coding and band hopping techniques is able to increase the diversity advantage significantly, thereby considerably improving the system performance. In case of single-antenna system, increasing the number of jointly encoded OFDM blocks from one to two yields the performance improvement of 6 dB at a BER of . By increasing also the number of transmit antennas from one to two, the proposed STF coded multi band UWB system has a total gain of 30 Db.

REFERENCES

[1] L. Hanzo, M. Mu¨nster, B. J. Choi, and T. Keller, OFDM and MC-CDMA for Broadband Multi-User Communications, WLANs and Broadcasting. Piscataway, NJ: IEEE Press/Wiley, 2003.

[2] L. Hanzo, S. X. Ng, T. Keller, and W. T. Webb, Quadrature Amplitude Modulation: From Basics to Adaptive Trellis-Coded, Turbo-Equalised and Space-Time Coded OFDM, CDMA and MC-CDMA Systems, 3rd ed. Piscataway, NJ: *IEEE Press*/Wiley, 2004.

[3] R. V. Nee and R. Prasad, OFDM for Wireless Multimedia Communications. London, U.K.: Artech House, 2000.

[4]. J. A. C. Bingham, BMulticarrier modulation for data transmission: An idea whose time has come, *IEEE Commun. Mag.*, vol. **28**, no. 5, pp. 5–14, May 1990.

[5]. W. C. Chung, N. J. Aug., and D. S. Ha, BSignaling and multiple access techniques for ultra wideband 4G wireless communication systems,. *Wireless Commun*, vol. **12**, pp. 46–55, Apr. 2005.

[6]. L. Hanzo, T. H. Liew, and B. L. Yeap, Turbo Coding, Turbo Equalisation and Space-Time Coding for Transmission Over Fading Channels. Piscataway, NJ: *IEEE Press/Wiley*, 2002.

[7]. J. H. Winters, B optimum combining in digital mobile radio with cochannel interference,[IEEE J. Sel. Areas Commun., vol. **SAC-2**, no. 4, pp. 528–539, Jul. 1984.

[8]. J.H. Winters, BOn the capacity of radio communication systems with diversity in a Rayleigh fading environment,[IEEE J. Sel. Areas Commun., vol. **SAC-5**, no. 5, pp. 871–878, Jun. 1987.

[9]. S. Ng and L. Hanzo, BOn the MIMO channel capacity of multi-dimensional signal sets,[in Proc. 60th IEEE Conf. Vehicular Technology, Sep. 2006, vol. 3, pp. 1594–1598.

[10]. G. J. Foschini, BLayered space-time architecture for wireless communication in a fading environment when using multi-element antennas,[Bell Labs Tech. J., vol. Autumn, pp. 41–59, Oct. 1996.

[11]. S. M. Alamouti, BA simple transmit diversity technique for wireless communications, *IEEE J. Sel. Areas Commun.,* vol. **16**, no. 8,
pp. 1451–1458, Oct. 1998.

[12]. V. Tarokh, A. Naguib, N. Seshadri, and A. R. Calderbank, BSpace-time codes for high data rate wireless communication: Performance criteria in the presence of channel estimation errors, mobility, and multile paths, *IEEE Trans. Commun.*, vol. **47**, no. 2, pp. 199–207, Feb. 1999.

[13]. T. Liew and L. Hanzo, BSpace-time block codes and concatenated channel codes for wireless communications, *Proc. IEEE,* vol. **90**, no. 2, pp. 187–219, Feb. 2002.

[14]. T.H. Liew and L. Hanzo, BSpace-time trellis and space-time block coding versus adaptive modulation and coding aided OFDM for wideband channels, *IEEE Trans. Veh. Technol.,* vol. **55**, no. 1, pp. 173–187, Jan. 2006.

[15]. J. Blogh and L. Hanzo. (2002). Third-Generation Systems and Intelligent Networking. Piscataway, NJ, IEEE Press/Wiley. [Online]. Available: http:// www-mobile.ecs.soton.ac.uk.

[16]. R. W. Chang, BSynthesis of band-limited orthogonal signals for multichannel data transmission,[*Bell System Tech. J.***,** vol. **45**, pp. 1775–1796, Dec. 1966.

[17]. European Telecommunication Standard Institute, Digital Audio Broadcasting (DAB);DAB to Mobile, Portable and Fixed Receivers, ETSI ETS 300 401 ed.1, Feb. 1995.

[18]. European Telecommunication Standard Institute, Digital Video Broadcasting (DVB); Framing Structure, Channel Coding and Modulation for Digital Terrestrial Television (DVB-T), ETSI ETS 300 744 ed.1, Mar. 1997.

[19]. European Telecommunication Standard Institute, Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H), ETSI EN 302 304 V1.1.1, Nov. 2004.

[20]. European Telecommunication Standard Institute, Radio Equipment and Systems (RES); HIgh PErformance Radio Local Area.