

Proposed Algorithm of Multiuser UWB system for Wireless Personal Area Network

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Abstract

In this paper we have proposed the algorithm based on ultra wide band (UWB) system which is applied on multiuser detection for wireless personal area network. We have measured bit error rate with respect to signal to noise ratio for pulse amplitude modulation (PAM) and pulse position modulation (PPM) technique based on different number of users. In the proposed algorithm interference is very low compared to conventional algorithm. By varying the number of users we have measured the bit error rate. As we increased the number of users the proposed algorithm detects signal efficiently compared to conventional algorithm. The proposed algorithm is based on the more fading environment that is where the fluctuation of amplitude, phase and delay is more and we have considered Rayleigh Channel. The simulation is based on the MATLAB software.

Keywords: Ultra Wide band (UWB), Pulse Amplitude Modulation (PAM), Pulse Position Modulation (PPM), Wireless Personal Area Network (WPAN), Bit Error Rate (BER), Signal to Noise Ratio (SNR).

1. Introduction

Ultra Wide band (UWB) radio is based on the radiation of waveforms, which are characterized by an fractional energy bandwidth greater than about 0.20-0.25. Ultra-wideband is a wireless technology that can operate at very low power spectral density (PSD) to communicate at high data rates over short distances. UWB was initially developed for military applications and in the current market it is adopted for civilian applications. UWB devices generally operate with respect to very narrow pulses thus it occupied very large emission bandwidths.

UWB can be integrated into a wide variety of applications including vehicular radar, radar imaging systems such as ground penetrating radar (GPR), and short-range wireless radio communication systems such as wireless personal area networks (WPANs). UWB technology could replace in part the need to connect different equipment with cables for the transmission of high data rate information. Some UWB applications are already available in the market such as ground penetrating radar systems and through-wall image detection systems. Other applications are at an advanced design and development stage.

The use of UWB for WPANs is expected to be a key application. The UWB industry is currently developing, through the Institute of Electrical and Electronics Engineers (IEEE), standards for UWB wireless networks. The availability of industry standards for UWB systems will facilitate the development of regulations and rules,

and will facilitate the introduction of UWB devices into the recent market.

The design of multi-user wireless communication system is based on the adoption of multiple access strategy by means of which users share the Hertzian medium under specified controlled levels of mutual interference. For multi-user wireless system various multiple access technologies are adopted like time division multiple access (TDMA), frequency division multiple access (FDMA) and code division multiple access (CDMA). In this paper we have discussed about the code division multiple access (CDMA) technology. A time hopping multiple access (THMA) falls in the CDMA category since different users adopt different codes, although in THMA, users are also separated in the time dimension. Each code has the effect of modifying the transmitted signal in such a way that a reference receiver is capable of isolating the useful signal from other users signals, which are seen by the reference receiver as interfering signals.

2. General Features of UWB

UWB technology has some features that are as follows:

1. Low susceptibility to multipath fading: Multipath fading can degrade the performance of conventional (non UWB) communication systems. In the case of UWB communications, the transmitted signal has a large bandwidth (very fine time resolution) and due to the narrow observation window at the receiver, multiple reflections with sub-nanosecond delays can be resolved

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and added constructively to provide gain compared to a single, direct path.

II. Immunity to interference: An important feature of UWB systems is their large processing gain, a measure of a system's robustness against interference.

III. Secure communications: UWB signals are more covert and potentially harder to detect than conventional radio communication signals. This is because UWB signals occupy large bandwidth, can be made noise-like, can communicate at a power spectral density level well below the noise floor of conventional radio communication receivers, and can communicate with a unique timing code at millions of bits per second. These features result in secure transmissions with low probability of detection (LPD) and low probability of interception (LPI).

IV. Relative system simplicity: In wireless communication systems that use UWB technology, the baseband information can be directly modulated using short pulses rather than modulating a sinusoidal wave. In this form of implementation, the UWB transceiver will have no phase-locked loop synthesizer, voltage-controlled oscillator, mixer, or power amplifier. This translates to a relative architectural simplicity compared to the super-heterodyne transceiver, and may lead to lower equipment costs.

V. Penetration properties: UWB emissions have good ability to penetrate walls and obstacles and provide high accuracy location determination. These properties would also be useful in applications such as medical imagery.

3. Multi-User UWB System Performance Based on the Gaussian Approximation

3.1 Binary Pulse Position Modulation with THMA (2PPM-HMA)

The binary PPM-THMA signal transmitted by user n as expressed by the following equation:

$$s_{TX}^{(n)} = \sum_{j=-\infty}^{\infty} \sqrt{E_{TX}^{(n)}} p_0(t - jT_s - c_j^{(n)}T_c - a_j^{(n)}\epsilon) \quad (1)$$

Where $p_0(t)$ is the energy-normalized pulse waveform and $E_{TX}^{(n)}$ is the energy transmitted over each single pulse. $c_j^{(n)}T_c$ is the time shift introduced by the TH code; $c_j^{(n)}$ is the j-th coefficient of TH sequence used by user n; and T_c is the chip duration.

For binary pulse position modulation with THMA, probability of error is given by,

$$Pr_b = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{\left(\left(\frac{E_b^{(1)}}{N_0} \right)^{-1} + \left(\frac{\gamma_R}{2R_b(N_u-1) \int_{-T_M}^{T_M} R_0^2(\tau) d\tau} \right)^{-1} \right)^{-1}}{2}} \right) \quad (2)$$

3.2 Binary Antipodal Pulse Amplitude Modulation with THMA (2PAM-THMA)

The binary antipodal PAM-THMA signal transmitted by user n as expressed by the following equation:

$$mui_p^{(n)}(\tau^{(n)}) = \sqrt{E_{RX}^{(n)}} \int_0^{T_M} p_0(t - \tau^{(n)}) p_0(t) dt \quad (3)$$

For binary antipodal pulse amplitude modulation with THMA, probability of error is given by,

$$Pr_b = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{\left(\left(\frac{2E_b^{(1)}}{N_0} \right)^{-1} + \left(\frac{\gamma_R}{R_b(N_u-1) \int_{-T_M}^{T_M} R_0^2(\tau) d\tau} \right)^{-1} \right)^{-1}}{2}} \right) \quad (4)$$

4. Simulation Results and Discussion

4.1 BER versus SNR for UWB system on WPAN for five users

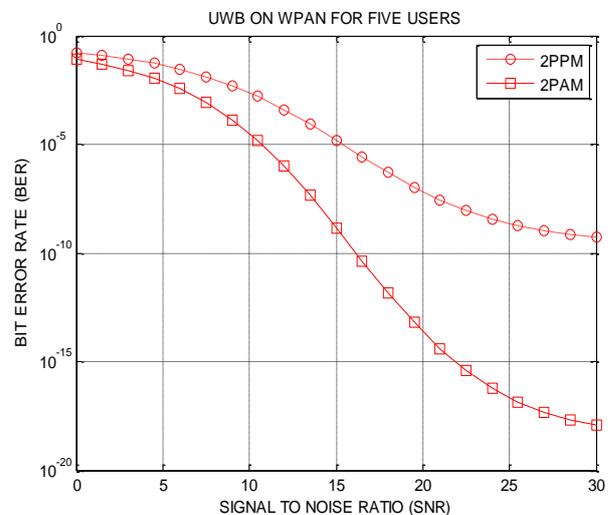


Fig. 1 BER versus SNR for UWB system on WPAN for Five users

From figure 1 it is seen that as SNR is increased BER is decreased. From figure 1, we say that for binary antipodal pulse amplitude modulation bit error rate is less compared to binary pulse position modulation. The figure 1 is for five numbers of users. From figure 1 it is seen that for SNR 30 dB the value of BER is around 10^{-20} for binary PAM-THMA signal and around 10^{-10} for binary PPM-THMA signal.

From table 1 we say that, as we increase the signal to noise ratio (SNR) the bit error rate (BER) is reduced. From table 1 we also say that the BER for binary PAM is less compared to BER for binary PPM technique. But again the BER mentioned in the table 1 for proposed technique is less compared to the conventional algorithm for UWB approach.

From table 1 we say that, for 0 dB SNR level the BER value is 0.0812 and 0.16179 for binary PAM and binary

PPM respectively. As we increase the SNR level the BER value is reduced. At the maximum SNR 30 dB the BER value is around 10^{-18} and 10^{-10} for binary PAM and binary PPM respectively.

Table 1 SNR V/S BER of UWB on WPAN for Five Users

Types of Technique	Binary PAM	Binary PPM
Signal to Noise Ratio (SNR) in dB	Bit Error Rate (BER)	Bit Error Rate (BER)
0	0.0812	0.16179
1.50	0.0492	0.12158
3	0.0256	0.08423
4.50	0.0108	0.05257
6	0.00357	0.02875
7.50	0.00084	0.01337
9	0.00013	0.00514
10.50	1.43660e-05	0.00159
12	9.66203e-07	0.00040
13.50	4.35555e-08	8.36498e-05
15	1.47152e-09	1.52998e-05
16.50	4.42042e-11	2.67869e-06
18	1.44022e-12	4.94750e-07
19.50	6.10949e-14	1.05178e-07
21	3.841825e-15	2.73259e-08
22.50	3.807280e-16	8.90737e-09
24	5.942948e-17	3.63125e-09
25.50	1.399987e-17	1.80963e-09
27	4.670220e-18	1.06760e-09
28.50	2.060905e-18	7.20966e-10
30	1.129878e-18	5.40507e-10

as increased the number of users BER is also increased because interference is also increased. But in the proposed algorithm BER is less compared to conventional algorithm.

Table 2 SNR V/S BER of UWB on WPAN for Twenty Users

Types of Technique	Binary PAM	Binary PPM
Signal to Noise Ratio (SNR) in dB	Bit Error Rate (BER)	Bit Error Rate (BER)
0	0.0888	0.1706
1.50	0.0578	0.1335
3	0.0341	0.0992
4.50	0.0180	0.0698
6	0.0085	0.0466
7.50	0.0036	0.0297
9	0.0014	0.0184
10.50	0.0005	0.0113
12	0.0002	0.0071
13.50	0.0001	0.0047
15	5.0421e-05	0.0032
16.50	2.7668e-05	0.0024
18	1.7105e-05	0.0019
19.50	1.1772e-05	0.0015
21	8.8677e-06	0.0013
22.50	7.1815e-06	0.0012
24	6.1514e-06	0.0011
25.50	5.4967e-06	0.00108
27	5.0682e-06	0.00106
28.50	4.7814e-06	0.00101
30	4.5865e-06	0.00099

4.2 BER versus SNR for UWB system on WPAN for twenty users

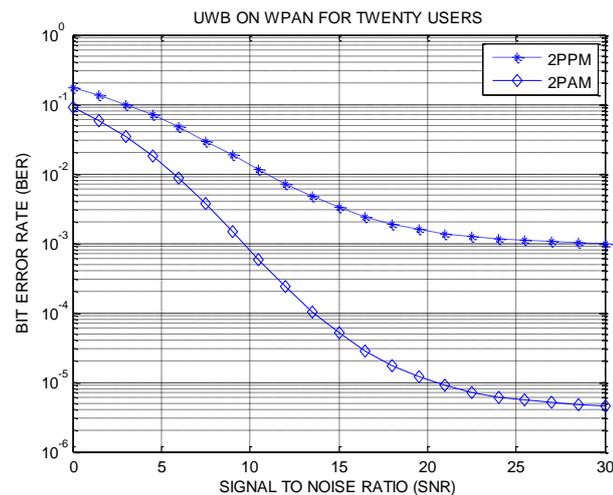


Fig. 2 BER versus SNR for UWB system on WPAN for Twenty users

From figure 2 it is seen that as SNR is increased BER is decreased. From figure 2, we say that for binary antipodal pulse amplitude modulation bit error rate is less compared to binary pulse position modulation. The figure 2 is for twenty numbers of users. From figure 2 it is seen that for SNR 30 dB the value of BER is around 10^{-6} for binary PAM-THMA signal and around 10^{-3} for binary PPM-THMA signal. So, from figure 1 and figure 2 we say that

From table 2 we say that, as we increase the signal to noise ratio (SNR) the bit error rate (BER) is reduced. From table 2 we also say that the BER for binary PAM is less compared to BER for binary PPM technique. Compare to table 1 and table 2 as we increase the number of users the BER is also increases for both the cases because the more number of users leads to the more interference (noise) level. But again the BER mentioned in the table 2 for proposed technique is less compared to the conventional algorithm for UWB approach.

From table 2 we say that, for 0 dB SNR level the BER value is 0.0888 and 0.1706 for binary PAM and binary PPM respectively. As we increase the SNR level the BER value is reduced. At the maximum SNR 30 dB the BER value is around 10^{-6} and 0.00099 for binary PAM and binary PPM respectively. So as we increase the number of users BER value is also increases. (Compare to table 1 and table 2)

4.3 BER versus SNR for UWB system on WPAN for fifty users

From figure 3 it is seen that as SNR is increased BER is decreased. From figure 3, we say that for binary antipodal pulse amplitude modulation bit error rate is less compared to binary pulse position modulation. The figure 3 is for fifty numbers of users. From figure 3 it is seen that for SNR 30 dB the value of BER is around 10^{-3} for binary

PAM-THMA signal and around 10^{-2} for binary PPM-THMA signal. So, from figure 1, figure 2 and figure 3 we say that as increased the number of users BER is also increased because interference is also increased. But in the proposed algorithm BER is less compared to conventional algorithm.

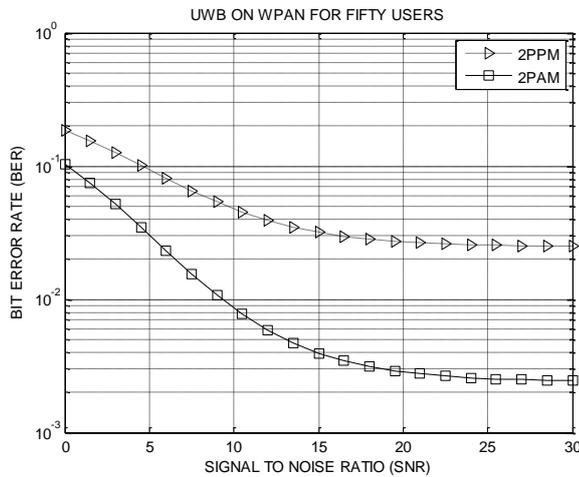


Fig. 3 BER versus SNR for UWB system on WPAN for Fifty users

Table 3 SNR V/S BER of UWB on WPAN for Fifty Users

Types of Technique	Binary PAM	Binary PPM
Signal to Noise Ratio (SNR) in dB	Bit Error Rate (BER)	Bit Error Rate (BER)
0	0.1030	0.1864
1.50	0.0744	0.1546
3	0.0515	0.1257
4.50	0.0346	0.1009
6	0.0230	0.0807
7.50	0.0154	0.0651
9	0.0106	0.0535
10.50	0.0077	0.0450
12	0.0058	0.0390
13.50	0.0046	0.0347
15	0.0039	0.0318
16.50	0.0034	0.0297
18	0.0031	0.0282
19.50	0.0029	0.0271
21	0.0027	0.0264
22.50	0.0026	0.0259
24	0.00256	0.0255
25.50	0.00252	0.0253
27	0.00249	0.0251
28.50	0.00246	0.0250
30	0.00244	0.0249

From table 3 we say that, as we increase the signal to noise ratio (SNR) the bit error rate (BER) is reduced. From table 3 we also say that the BER for binary PAM is less compared to BER for binary PPM technique. Compare to table 1, table 2 and table 3 as we increase the number of users the BER is also increases for both the cases because the more number of users leads to the more interference (noise) level. But again the BER mentioned in the table 3 for proposed technique is less compared to the conventional algorithm for UWB approach.

From table 3 we say that, for 0 dB SNR level the BER value is 0.1030 and 0.1864 for binary PAM and binary PPM respectively. As we increase the SNR level the BER value is reduced. At the maximum SNR 30 dB the BER value is around 0.00244 and 0.0249 for binary PAM and binary PPM respectively. So as we increase the number of users BER value is also increases. (Compare to table 1, table 2 and table 3)

Conclusions

In this paper we have proposed the algorithm based on ultra wide band (UWB) system which is applied on multiuser detection for wireless personal area network. As the number of user is increased BER is also increased due to the increased in the interference. But in the proposed algorithm BER is less compared to the conventional algorithm. The proposed technique is applied on the wireless personal area network with respect to the PAM-THMA and PPM-THMA algorithm. From the simulation results and from table 1, 2 and 3 we say that lowest value of BER is achieved with respect to the proposed algorithm.

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