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Performance Analysis of UWB System

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Abstract— ***UWB (Ultra Wide - Band) is one of the most developing technologies in modern mobile communications. UWB is a technology that can use very low energy level for short-range and high-bandwidth communications over a large portion of the radio spectrum. It is used for transmitting large amounts of the digital data over a wide spectrum of frequency bands with very low power for short distance. No frequency diversity is exploited to improve bit error rate performance. A performance analysis of UWB system in multipath fading and additive white Gaussian noise (AWGN) channels is presented here. The analysis proceeds in the two steps. First, design a simple UWB system with the same bandwidth. Second, a binary modulating signal with same bit rate is transmitted over the system and the bit error rate in multipath fading channel and additive white Gaussian noise channel is observed.***

***Index Terms*—Carrierless, Encoding, Modulation, QASK, QPSK.**

I. Introduction

UWB is referred in broad terms as "carrierless" or the impulse technology. The term UWB was coined in the late 1980s to depict the development, transmission, and reception of ultra-short pulses of RF energy. For various communication applications, high data rates are possible due to large number of pulses that can be created in a short time duration.

Due to its low power spectral density, ultra wide band can be used in military applications that need low probability of detection. Other general uses of UWB are in radar and imaging technologies, where the ability to resolve the multipath delay is in nanosecond range, allowing for finer resolution, may it is from a target or for an image.

After recognizing the probable advantages of UWB, the Federal Communication Commission developed a report to allow UWB as a communications and imaging technology. It is referred to as "baseband", "impulse" or "carrier free", and it has been planned for unlicensed operations over bandwidths spanning numerous GHz, provided that the power spectral density of transmitted signals is fanatic to some emission masks (as specified by the Federal Communication Commission in the USA) recommended by coexistence issues with other systems[1]. A typical UWB signal is composed through the transmission of ultra short pulses having several Gigahertz bandwidth which enhance the capacity to distinguish between the multipath replicas of the received signal and reduce fading effects in indoor environments when proper diversity reception techniques are used in combination to adequate channel estimation algorithms.

A UWB definition was created as a signal with a fractional bandwidth which is greater than 0.2. The fractional bandwidth is defined as $2(f_H – f_L)/(f_H + f_L)$, where f_H and f_L are upper and lower frequencies correspondingly, measured at -10 dB below the peak emission point. Prior to recent industry boom with these standards, the most general UWB system implementation was the impulse radio, where ultra-short baseband pulses are used with a diversity of modulation schemes to transfer the data.

II. Principle

The method for generating an ultra wide band signal has existed for more than three decades, which is better identified to the radar community as a baseband carrier fewer short pulse. A classical way to generate an UWB signal is to spread the data with a code with a extremely large processing gain, i.e., 50 to 60 dB, resulting in a transmitted bandwidth of numerous GHz. Multiple access can be realized by classical CDMA where for each user a given separate spreading code is assigned.

However, the main complexity of such a technique is its implementation. As the power spectral density of the UWB signal is extremely low, the transmitted signal appears as a negligible white noise for the other systems. In the increasingly crowded spectrum, the transmission of the data as a noise-like signal can be considered a major advantage for the UWB systems.
However, its main drawbacks are the small coverage and the low data rate for each user. Typically for short-range applications (e.g., 100 m), the data rate assigned to each user can be about several kbit/s. An alternative approach compared to the classical CDMA is proposed for generating an UWB signal that does require sine-wave generation. It is based on time hopping spread spectrum technique. The key advantages of time hopping spread spectrum method is the ability to resolve multiple paths and the low complexity technology availability for its implementation.

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III. GENERATION OF UWB SYSTEM

UWB techniques are considered as a means to efficiently use radio resources since they allow a simple multiuser and multi-standard access by spreading the information on a very large spectrum. Currently, WPAN stem as the most promising application, as the U.S. FCC has endorsed UWB use in short-range communication systems. For this reason, UWB has also been included for WPANs, implemented as a combination of Time Hopping and Direct Sequence spreading, while modulation is performed as a mixture of pulse amplitude modulation and pulse position modulation. A UWB transmission scheme is illustrated in Figure, where for each user a given time-hopping pattern, i.e., PN code, is assigned to it. The transmitter is quite simple and it does not include any amplifier or any IF generation.

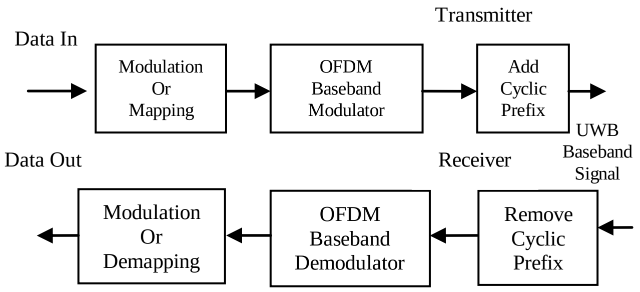

Fig 1 Transmitter Receiver of UWB system

The input data is mapped according to the modulation technique generally QPSK, QAM etc. and this mapped data is then spread in OFDM baseband modulator where it is multiplied with PN sequence and generates short duration pulses. The signal of the transmitted data after pulse position modulation (PPM) according to the user's PN code is emitted directly at transmitter antenna. A critical point of the transmitter here is the antenna which may act as a filter[2]. The receiver components are similar to the transmitter components. A receiver as in a conventional DS-CDMA system might be required to cope with the multipath propagation. The baseband signal processing extracts the modulated signal and controls both the signal acquisition and tracking.

IV. FEATURES OF UWB SYSTEM

The ultra – wide band system has following features:

a) Extremely low signal power spectral density: Since the bandwidth of the UWB signals is much wider than that of the conventional wireless systems, a higher channel capacity can be achieved even in a low SNR environment. Because of the low signal power and available large bandwidths, UWB systems perform like spread spectrum system. However compared to the more common forms of the spread spectrum system like frequency hopping and direct sequence systems, UWB does not rely on a spreading sequence and hopping sequence to generate the wide bandwidth signals. Instead, it is the extremely short duration of the UWB pulse that gives the system its ultra-wide bandwidth. Compared to the additional narrow band communication systems, which function is in the bandwidth-limit regime, ultra wide band works in the power limit regime. Therefore, the ultra wide band signal power in single narrow frequency channel is very small and interference to any other existing products can be ignored[3].

b)Robust to multipath interference: UWB is robust to the effects of the multipath interference. Because the signal bandwidth of UWB is much greater than coherence bandwidth of a multipath channel, any frequency-selective fading just affects small portion of signal spectrum for any channel realization. The interval time between the two continuously transmitted UWB pulses determine the maximum observable multipath delay. Hence the multipath components with differential delay larger than half the pulse width and within one period of periodic pulse transmission can be measured without any mistake. Since the time resolution is approximately equal to reciprocal of the bandwidth, the use of signals with GHz bandwidth means that the multipath is resolvable down to path differential delays in the order of nanoseconds or less, i.e., down to path difference in the order of 0.3 meters or less. This significantly reduces the fading effects even in indoor environments. Lack of significant multipath fading may considerably reduce the fading margins in link budgets and allow for a low transmission-power operation. The capability to highly resolve the multipath combined with the ability to penetrate through the materials makes UWB technology valuable for the high-quality, fully mobile short-range indoor radio systems.

c) Reduced fading effects in the indoor environments when the proper diversity reception techniques are used.

d) Best for radar community as baseband carrier has less short pulse.

e) The transmitted signal appears as a noise for other system.

f) Small coverage area.

V. MODULATION TECHNIQUES

A. *Quadrature Amplitude Modulation*

QAM (a method of combining two amplitude modulated signals into a single channel, thereby doubling effective bandwidth). QAM is used with pulse amplitude modulation in the digital systems, especially in various wireless applications. In a QAM signal, there are two carriers, each one having the same frequency but differ in phase by 90 degrees (1 quarter of a cycle, from which the phrase quadrature arises). One signal is called the I signal, and the other is called Q signal. Mathematically, one of the two signals can be represented by sine wave, and the other by cosine wave. The two modulated carriers are combined at the

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source for the transmission. At the destination, the carriers are separated, and the data is extracted from each, and then data is combined into original modulating information.

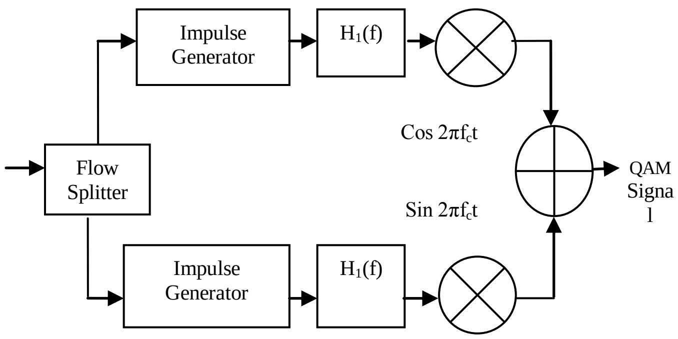

Fig 2 Quadrature Amplitude Modulation

This is the most complicated step in OFDM system. The binary stream must be converted into an actual OFDM waveform. The technique used in this simulation is known as the QAM or quadrature amplitude modulation. Before this technique can be implemented, the binary stream created in the previous step must be separated into the blocks of 8-bits. Then this block of 8-bits must be further broken down into the sets of 2- bits. These 2-bit sets are then converted into a waveform using Equation QAM Modulated signal $S(t) = A\,Cos(\omega_0 t) + B\,Sin(\omega_0 t)$ and suppose the data is [0 0 0 1 1 0 1 1] it can be divided into set of 2 – bit each and converted into [00 01 10 11] .

B. *Quadrature Phase Shift Keying Modulation*

The data which is to be transmitted on each carrier is then differentially encoded with previous symbols, which is then mapped into a phase shift keying format. Since the differential encoding require an initial phase reference that is why an additional symbol which is added at the start for this purpose. The data on each symbol is then mapped to a phase angle based on the modulation method used. For example in QPSK the phase angles used are 0, 90, 180, and 270 degrees. The use of the phase shift keying produces a constant amplitude signal and was chosen for its simplicity and to reduce problems with amplitude fluctuations due to fading. The QPSK Modulator Baseband block modulates using quaternary phase shift keying method. The output is the baseband representation of the modulated signal. The main parameters of QPSK block are input type, constellation ordering, phase offset and the samples per symbol. The input type parameter specifies whether the input is of Boolean type, single type or double type. In constellation ordering one can choose two types of ordering binary or gray and the phase offset is used to choose the angle of phase shift. The samples per symbol tells that how many samples are used to position the symbol.

VI. ENCODING SCHEMES

Block Encoder

To achieve satisfactory performance in application of UWB, the addition of some form of coding is needed. High signal to noise ratio are required to achieve reasonable bit error rate in the presence of fading channel. Proper coding is very important for UWB. There are several factors should be taken into account, such as the required coding gain, channel characteristics, source coding requirement, modulation.

An encoder is a device, software program, algorithm or person that convert information from one format or code to another, for the purpose of standardization, speed, secrecy, security, or saving space by shrinking size. In this system for analysis of different encoding schemes Cyclic Redundancy Code and Reed – Solomon encoding schemes are used.

Cyclic Redundancy Code Encoding

The General CRC Generator block generates the cyclic redundancy code bits for each input data frame and appends them to the frame. We specify the generator polynomial for the CRC algorithm using the Generator polynomial parameter. This block is in general the sense that degree of the polynomial does not need to be power of two.

If the size of the input frame is m and degree of the generator polynomial is r, the output frame has a size of $m + k * r$. For Example: Suppose the size of input frame is 10, the degree of the generator polynomial is 3, Initial state is [0], and Checksums per frame is equal to 2. The block divides each input frame into two subframes each of size 5 and appends a checksum of size 3 to each of the subframe, as shown below. The initial states are not displayed in this example, because an initial state of [0] does not affect the output of CRC algorithm. The output frame then has a size 5 + 3 + 5 + 3 = 16.

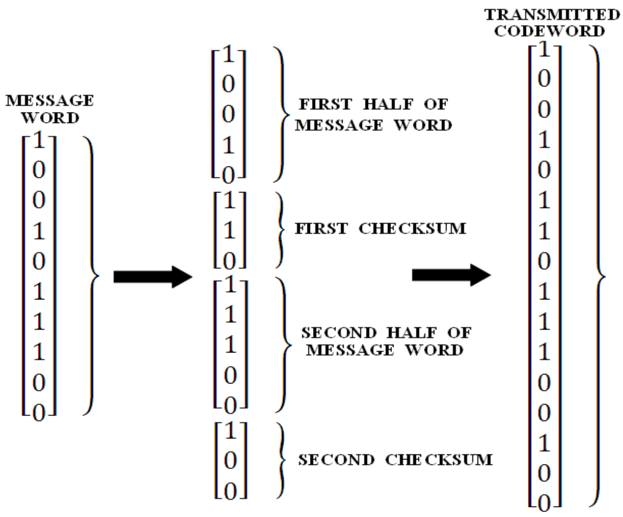

Fig 3 CRC Encoding

In this model the cyclic redundancy code is an encoding software program or algorithm that converts information from one format or code to another, for various purposes of standardization, speed, secrecy, security,saving space by shrinking size.

Reed – Solomon Encoding

The Binary-Input RS Encoder block creates a Reed-Solomon code with the message length of K and codeword length of N by specifying both N and K directly in the dialog box. The symbols for both the code are of binary sequences of length M, corresponding to the elements of the Galois field GF(2^M), where the first bit in each sequence is the most significant bit (MSB).

Suppose M = 3, N = 2^3-1 =7, and K = 5. Then a message is a binary vector of length 15 that represents the 5 three-bit integers. A corresponding codeword is the binary vector of length 21 that represents the 7 three-bit integers. The following fig shows the codeword that would result from particular message word. The integer format equivalent illustrate that the highest order bit is at the left side.

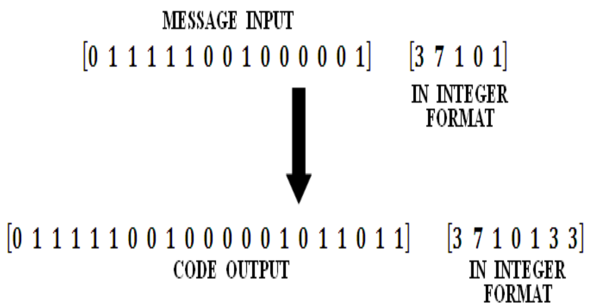

Fig 4 RS Encoding

VII. CONCLUSION

There are various air interface technologies in modern mobile communication. The two well known modern interface technologies include the Orthogonal Frequency Division Multiplexing (OFDM) and Ultra Wide Band System (UWB). OFDM is a frequency division multiplexing method utilized as digital multi-carrier modulation method. A large amount of closely – spaced orthogonal sub-carriers are used to carry the data.

UWB is referred to as “baseband”, “impulse” or “carrier free” system. A typical UWB signal is composed by the transmission of the ultra short pulses having a several Gigahertz bandwidth which enhances the capacity to differentiate multipath replicas of the received signal and reduces the fading effects in indoor environments when the proper diversity reception techniques are used in conjunction with adequate channel estimation algorithms.

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