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ULTRA WIDEBAND MODULATION PERFORMANCE IMPROVEMENT AND ADVANTAGES OVER CONVENTIONAL NARROWBAND SYSTEMS

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Abstract

Ultra-Wideband (UWB) technology is a wireless transmission scheme that occupies a bandwidth of more than 25% of a center frequency, or more than 1.5GHz. It uses very narrow band pulses of nano-seconds duration to provide very high data rate communications. The pulses in the UWB spread the energy of the signal over a large frequency range because of which it is called ultra-wideband. In this paper, we will discuss the UWB modulation system techniques using gaussian pulse its advantages and performance improvement compared with the conventional narrowband systems of transmission.

***Keywords**: UWB, PPM, BPM, PAM, FCC.*

Introduction

UWB history is generally perceived to start after 1960 with the development of Linear Time Invariant System description via impulse stimuli. On the contrary, UWB transmissions history is much longer and goes back to the end of 19th century. During that time, telegraphy was already wide-spread but it was suffering because of the long wired connections which were difficult to be built and maintained.

Through the late 1980's, UWB technology was referred to as baseband, carrier-free or impulse technology. It was not until 1989 that the U.S. Department of Defense applied the term "ultra wideband". By that time, development of techniques using this technology had been under development for nearly 30 years.

During the late 2000 the UWB research focused more on communication methodology and commercial short-range wireless applications such as wireless LAN and home entertainment

The UWB signal's spectrum can be several gigahertz's wide. The common pulse shape for UWB communication system is the Gaussian pulse and its derivatives due to ease of generation. The Gaussian pulse is defined as

Where σ is the standard deviation of the Gaussian pulse, and μ is the location in time for the midpoint of the gaussian pulse in seconds [4] [5].

UWB Emission Mask

The FCC mask depicts the allowed power spectral densities for specific frequencies for the indoor UWB communication system. Figure 1.2 illustrates the FCC radiation limits.. For the indoor

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and outdoor UWB communications, the FCC radiation limits in the frequency range of 3.1–10.6 GHz are alike.

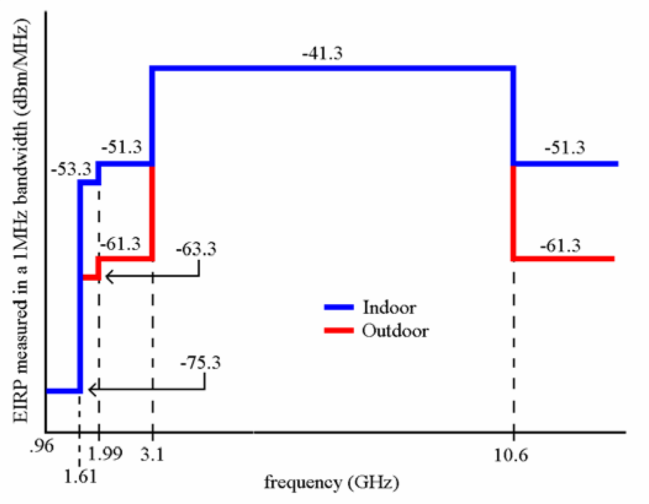

Fig1. UWB emission mask

Modulation Techniques

UWB can directly modulate impulse pulses of nano-seconds duration that results in a waveform that occupies several GHz of bandwidth[3].UWB signals are obtained by either applying the Pulse Position (PPM), Pulse Amplitude (PAM), Bi-Phase modulation

A. PPM Modulation

In PPM modulation, each pulse is sent in advance or delayed to a regular time scale. A binary communication system can be established with a forward or backward shift of the pulse in time.

The data is encoded by adding an extra time shift ‘‘ δshift’’ to the impulse as shown in the Fig2

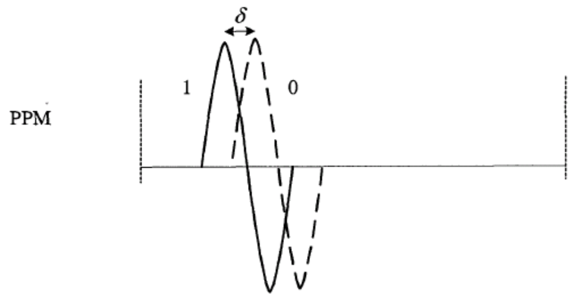

Fig.2. PPM Modulation

B. PAM Modulation

The second data modulation scheme is pulse amplitude modulation (PAM), which is based on encoding the data in the amplitude of the impulses.Fig.3. shows a PAM modulated signal.

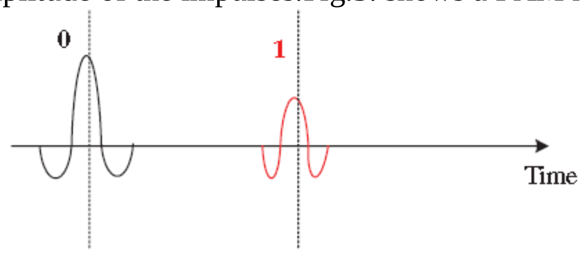

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Fig.3. PAM Modulation

C. Bi-phase modulation (BPM)

In Bi-phase modulation (BPM) we invert the pulse, to create a pulse having opposite phase. This is known as. Bi-phase is therefore antipodal as shown in Fig.4.

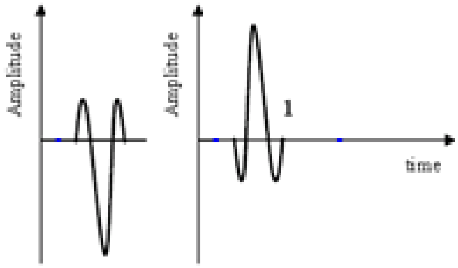

Fig.4. Bi-phase Modulation

Advantages of the UWB

I. **Power Consumption:-** UWB radio offers short-range communication that uses 1/1000 of the power required for equivalent conventional transmission methods.
II. **High Security**:- Because of their low average transmission power, UWB communications systems have an inherent immunity to detection and interception.
III. **High Performance in Multipath Channels:-** The phenomenon known as multipath interference is unavoidable in many wireless communications channels. When signals are transmitted between transmitter and receiver, they scatter, reflected from objects and surfaces along the path. At the receiver end, the receiver sees the superposition of delayed versions of the original signal. When signals are continuous-waves or sinusoidal waveforms, these 'replicas' may cancel the original signal due to the phase difference of the signals. UWB communication uses pulse waveforms and they tend not to overlap in time because of the extreme narrowness of the pulse.
IV. **Resistance to Interference** Because of their low power spectrum density, unlicensed UWB radios will cause no interference to other radio systems operating in dedicated bands.
V. Allows spectrum reuse
VI. It has immunity to multipath and interference
VII. **High-speed:-**UWB signals have the capability to convey high-speed data. It has wide frequency bandwidth; it is inherently suited for high data rate communications. For instance the data rate of the IEEE 802.15.3a UWB proposals can achieve up to 480Mbps. This is a giant leap from the existing 1 Mbps of Bluetooth, 11 Mbps of 802.11b, and 54 Mbps of 802.11a/g.

Improvement from Conventional Narrowband Systems

Currently, the following conventional wireless standards, i.e., Bluetooth, IEEE802.11a, IEEE802.11b, and IEEE802.11g are commonly used.

A. 802.11a

IT works on OFDM technology. Its frequency spectrum occupies 300 MHz in three different bandwidths of 100 MHz each. lower band (5.150 to 5.250 GHz), UNII middle band (5.250 to 5.350 GHz), UNII upper band (5.725 to 5.825 GHz). 802.11a provides 12 channels of 20 MHz each and can offer data rate up to 54 MHz. has a range of about 20 meters in free space and spatial capacity of approximately 515 Kbps/m^2.

B. 802.11b

It employs direct sequence spread spectrum (DSSS) with complementary code keying (CCK) base-band modulation. Its RF spectrum occupies 83.5 MHz bandwidth from 2.4 GHz to 2.4835 GHz. 802.11b has 11 channels, each of which is 22 MHz wide, and offers data speeds up to 11Mbps. It has a range of about 100 meters and spatial capacity of approximately 1 Kbps/m^2

C. **Bluetooth**

Bluetooth, also known as the IEEE 802.15.1 standard is based on a wireless radio system designed for short-range and cheap devices to replace cables for computer peripherals, such as mice, keyboards, joysticks, and printers. A contemporary example of a low-cost, short-range wireless architecture is the Bluetooth radio, an example of which is shown in Fig.5.

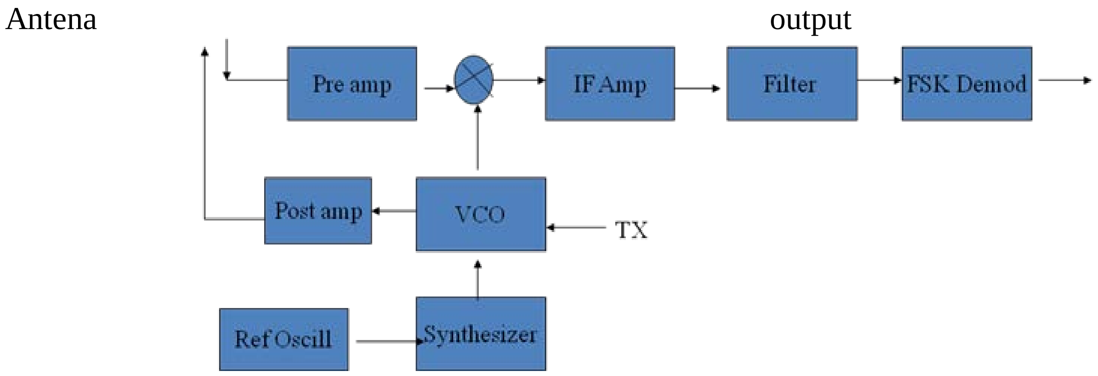

Fig.5. Bluetooth transceiver

Bluetooth uses a form of Frequency Shift Keying (FSK) where information is sent by shifting the carrier frequency high or low. The information bits applied to a Voltage-Controlled Oscillator (VCO). A synthesizer with a crystal reference oscillator is required to keep this oscillator's average frequency within specific limits. This 1MHz-wide signal is then spread to 79MHz by a frequency-hopping technique where the synthesizer is tuned to pseudo random channels spaced at 1MHz. The resulting emitted signal is centered at 2.45GHz with a bandwidth of 79MHz.
In receive mode, the signal from the antenna is first amplified and then down-converted to an Intermediate Frequency (IF). The down-converter uses a heterodyne technique where a non-linear "mixer" is fed both the desired signal at ~2.45GHz and a synthesized local oscillator. The mixer produces a plethora of images of the desired signal where each image is centered at the sum and difference terms of the desired signal and the local oscillator. The signal that falls at the desired IF frequency then passes through the IF filter, while the other signals are rejected.
Bluetooth, in its low-power mode, has a rated 10-meter range and a peak over-the-air speed of 1Mbps.

UWB Transceiver

The UWB transceiver could be used for the same applications targeted for use with Bluetooth, but at higher data rates and lower emitted Radio Frequency (RF) power. The information could be modulated using several different techniques like Pulse Position, Pulse amplitude, Bi phase etc. The pulse has duration on the order of nano seconds and its shape is designed to concentrate energy over the broad range of 3-6GHz. A power amplifier may not be required in this case because the pulse generator need only produce a voltage swing on the order of 100mV.

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In receive mode, the energy collected by the antenna is amplified and passed through either a matched filter or a correlation-type receiver. A matched filter has an impulse response matched to the received pulse shape and will produce an impulse at its output when presented with RF energy which has the correct (matching) pulse shape. The original information is then recovered with an adjustable high-gain threshold circuit.

So we can see that**,** It has no reference oscillator, no synthesizer, no VCO and no need of carrier frequency adjustment. Thus UWB systems vary widely in their projected capabilities, but one UWB technology developer has measured peak speeds of over 480 Mbps at a range of 10 meters with spatial capacity of approximately 1000 Kbps/m^2

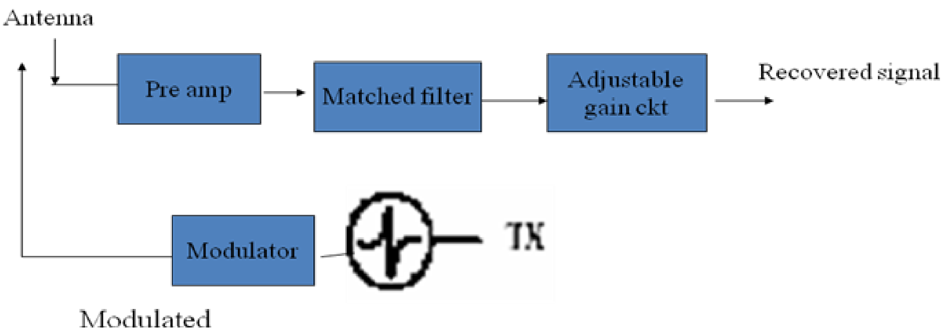

Fig.5. UWB transceiver

Some key characteristics of Conventional narrowband system Standards and UWB technology are summarized below in Table 1.

Table1. Key characteristics of existing wireless standards and UWB technology

Technology	Operating range	Peek speed	Modulation	Frequency Band	Capacityin bits/sec/sqm
IEEE802.11a	50 m	54 Mbps	OFDM	2.4 GHz	515 Kbps/m^2.
IEEE802.11b	100 m	11Mbps	FHSS	2.4 GHz	1 Kbps/m^2
Bluetooth	10 m	1Mbps	OFDM	2.4 GHz	30 Kbps/m^2.
UWB	10 m	480 Mbps	Multi-band OFDM	3-10GHz	1,0000 kbps/m^2

Conclusion

In this paper UWB modulation system performance improvement in terms of the advantages over conventional narrowband wireless systems are explained. From above facts it is concluded that UWB system has very high peak speeds of over 480 Mbps at a range of 10 meters with very less power consumption and power spectral density as compared to bluetooth standard which operates with in the same 10 m range. Also UWB systems have better spatial efficiency over all other existing wireless standards. Since the average power consumption of a UWB transmitter grows linearly with Pulse Repetition Frequency (PRF), it is easy to envision a relatively simple UWB radio that, under software control, can dynamically trade data rate, power consumption, and range. This type of flexibility is what is needed to enable the power constrained portable computing applications of the future.

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