UWB System: Its Regulations, Trends and Applications

Sophiya Susan S', Siva S Yellampalli

Abstract*: This paper presents the Regulations of UWB, its advantages over the existing technologies and its importance towards communication. Paper reviews existing applications on Ultra-Wideband technology in various field. Our aim is to understand the existing solutions and approaches for UWB system and to bring out its advantages and its disadvantages. Finally, the design Challenges for UWB its Spectrum provision in India.

***Index Terms*: FCC, Data rates, Frequency Spectrum, Short range communication, narrow pulses**

I. INTRODUCTION

The new era of communication technology started, UWB has been one of the leadings research topics in the community [1],[2]. Researchers are examining its effectiveness in various directions. UWB technology is the technique that has evolved for short range communication. The release of a wide band spectral masks unlicensed uses 3.1GHz to 10.6GHz by American federal Communication Commission (FCC) for ultra-wideband (UWB) technology has been an active research field. Implementation of UWB to generate very narrow pulses in the range of picoseconds is challenging. The feature of this technique is that it's a Baseband signal approach, where the key feature is the absence of carrier signal.

II. REGULATIONS

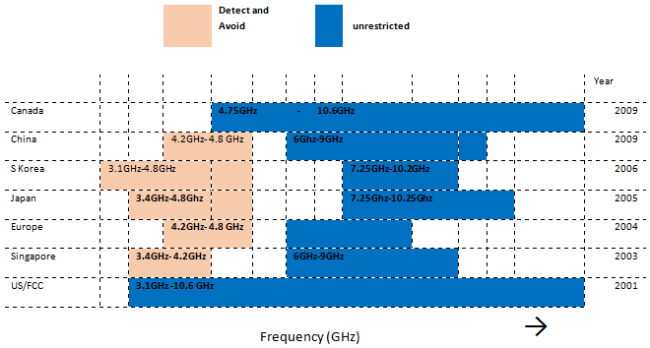
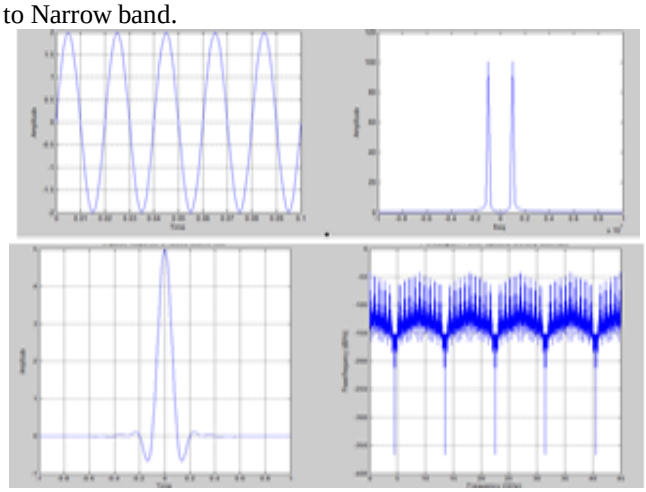


Fig. 1 Wireless communication UWB bands allotted [3]

A. Why UWB a Solution for high data Rates in communication:

Ultra WB is one of the possible solutions for applications that is required for high data rate - shorter range communication. This is due to the use of narrow pulses which occupies lesser width in time domain and widely spread in frequency fig2 [3]. It's a low power circuit since it uses narrow pulses that require less power to convey the data as compared to Narrow band.



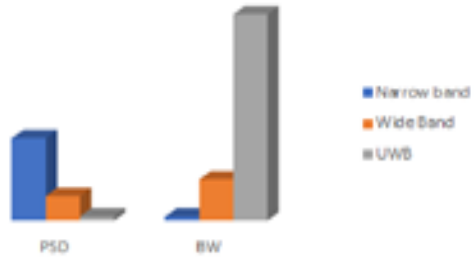
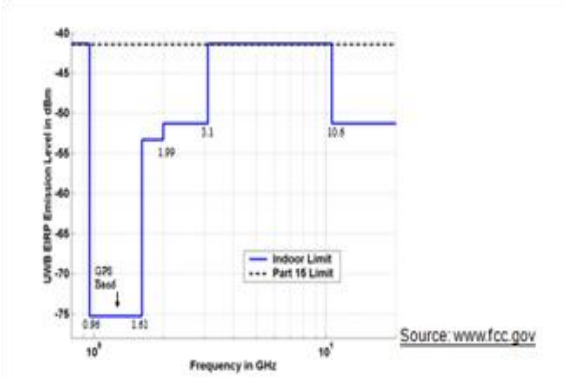


Fig 2 Bandwidth and Power Spectral Density [3]



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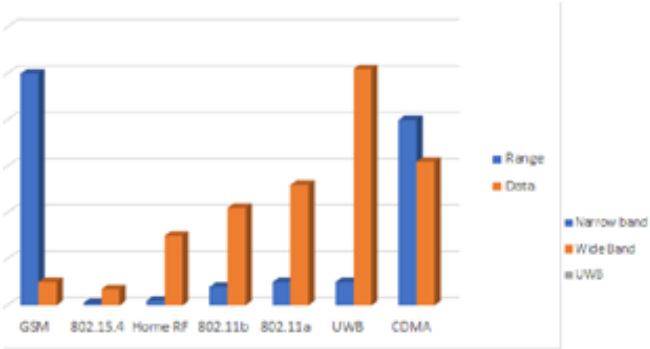

Fig 3 UWB Emission Limit for Indoor System [3].

As the power spectral density is low for UWB, it reduces the inference with other system as indicated in fig 3 [3] . Also, Data Rate is equal to twice the Bandwidth. Henceforth in UWB signal, the bandwidth is much higher than the conventional Narrow band signal, thereby higher data rate and lesser distortion due to narrower signal width. UWB communication system is the cure for high data rate short range communication environment. The comparison with other wireless communication is shown in fig 4. UWB is one of the solutions for high data rate and low power compared to other standards as indicated below

Table.1 **Comparison between indoor Wireless Communication**

Comparisons Between Indoor Wireless Communication System			
	Blue Tooth 3.0	Wi-fi	UWB
Transmission Rate	up to 3 Mbps	up to 54Mbps	1Gbps
Range	10 meters	45 meters (Indoor)	10 meters
Power Consumption	2.5mW(10m) 1mW(1m)	100m W	0.5mW
Interference	Both uses the unlicensed 2.4Ghz Spectrum, which often crowded with each other and devices such as microwave ovens, cordless phones, video sender devices, and among many others. This may cause degradation in performance.		No interference to the narrowband system in dedicated bands and does not interfere with regular radio services.
Security	Both are susceptible for spying and remote access. Access points could be used to steal personal and confidential information transmitted from users		Signals are like background noises, it is immune to detection and interception by other narrowband receivers

B. Technical Approaches to UWB System

Allotted larger Bandwidth is to support high data rates as well as low power due to narrower pulse

Approaches for the development of UWB systems:

There are two main **approaches Multiband OFDM and Impulse Radio.**

- Applications where high data rates say 500Mb/s are required such as video streaming and wireless USB the Multiband -OFDM is preferred.
- Applications which has constrains in energy such as Personal Area Networks, sensor application, tag Networks and Biomedical Impulse Response system is preferred.

Some of the properties of UWB are its highly secured since the signal appears like noise for unintended users as well as for other system hence lesser interference. Both LOS and NLOS operation and can pass through walls and objects also low cost and low power.

III. APPLICATIONS OF UWB

A. UWB Communications

UWB for Communications include high Speed WLANs in short-distance for instance PC peripherals., location based systems, Mobile Ad-Hoc networks as well as Intra Home Communication such as data from digital camcorders. In [6] 3GHz to 5 GHz CMOS Impulse Radio Ultra wideband architecture of Transceiver which is fully integrated is proposed which is suitable for location-based application system that uses an Analog to Digital converter of 4 bit. The Transceiver designed provides tunable UWB signal that follows the FCC regulations as well as its low power synthesized digital transceiver. It's mainly proposed for short range purpose that covers about 8mthrough cable and its extended up to 80m. Achieved a current consumption of 30mA at receiver and 26mA at transmitter as well as sensitivity in the range of -86 dBm There are numerous problems [26] related to navigation systems dealing with indoor positioning systems. GNSS (Global Navigation satellite Systems) is one of the proposed solutions, which has drawback of less accuracy. But taking an advantage for high immunity to interference as well as multipath propagation. UWB seems to be a very good candidate as a solution for GNSS.

B.UWB for Consumer based applications:

1-UWB based connectivity to portable under research for future SMART networks **[7].**

2- UWB can be used for the Wireless Universal Serial Bus connectivity with standard computing nodes (e.g., printers, and scanners).

3- UWB could be a good candidate for the next generation Bluetooth technology devices, such as smartphones [8]**.** For all three possible uses, spectrum is an active concern due to the absence of standardized spectrum. In [8] concludes that despite of all the bottlenecks and challenges UWB's efficient capabilities makes it an attractive scheme for the WSN, provided we can control interference and energy problems.

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C. Features of UWB in the field of Medical.

As UWB pulse has short pulse width in terms of Nano or picoseconds makes it advantageous in medical application. The following section discusses the features of UWB in particular area of application

Penetrate through obstacles

Due to the features of UWB the signals are able to penetrate through the obstacles. The UWB signals [9] are mainly used for detection of any pathology of human parts as well as for observation of patient's activities. Latest trends of UWB are in the field of detection of cancer cells in early stages for dangerous cancers such as breast cancer through the properties of UWB. This is possible because difference in the dielectric constant between a tumor and breast tissues. Many techniques have been suggested [10]-[14] involving image processing algorithms as well as a process known as tomography.Furthermore, issues such as blood flood or pulmonary oedema are also emerging areas of research [15]-[16]. As well as UWB for monitoring health condition of patients such as heart beat, Blood pressure, communication which uses sensors respiration and urine retention issues [17]-[19]. Many activities are carried out for body communication using sensors related to Wireless Body Area Network. In the field of medical there is an excellent improvement both in technology as well as the techniques which helps to diagnose in a better way [9]. Few parameters such as resolution as well as acquisition which determines the specific problem such as pulmonary oedema, respiratory problem, urine retention in the bladder or breast cancer. Due to the non-ionizing property of UWB it is not having negative impacts as x-ray or CT where measurements are repeated.

In [9] human body such as head or breast etc. can be modeled as an approximation of multilayer structure in which each layer is considered as a particular tissue. For instance, the body structure includes skin, fat and then muscles. Likewise, multilayer head structure includes skin, fat, skull, brain etc. Each tissue or the layer has its relative permittivity which is dependent on frequency as well as conductivity, density and its thickness. The reflected field that is originated is the difference between the layers. This makes UWB facture applicable in the field of medical.

Precision qualities of UWB at a distance of centimeter

The feature of high range of precision at a distance of centimeter is the key feature of UWB pulse. Multipath resolution capabilities as applied to UWB positioning which includes tracking persons, assert monitoring, car parking and surgical navigations. Few investigations on high accuracy which is a key requirement for surgical navigation is discussed [20] which emphasis on the challenges concerned to positioning system of UWB. In the proposed a UWB positioning system which aims to achieve sub millimeter accuracy [21]. Which includes oscillators which reduces the phase noise both in Tx as well as receiver which is dielectric resonator oscillator, the next is the AGC for better operating range and a band pass filter to mitigate the interference of IEEE 802.11a/n.

The non-invasive method of detection of vital sign is an important application such as victim's search, rescue, monitoring the physiological characteristics as well as sleep apnea detection. In [22] using UWB radar suggests the way to monitor sign of stationary human who is in the remote place. As well as its advantages over the wearable technology. Using small radars various algorithms have been proposed for detection of respiration as well as heart beat rates. In [23] complex signal demodulation (CSD) is proposed but the interference of heart beat and respiration becomes dominant. As a solution to this inference various other modulations have been suggested. Such as arctangent demodulations [24] as well as differentiate and cross multiply [DACM] [25]. In [22] a signal processing technique that's used for detection of a stationary person without any interference is considered, where the adaptive filter is applied to locate frequency region using numerical analysis.

3c. Low electromagnetic radiation

This feature of UWB finds in hospital applications and safe for human body due to low radiation. According to regulations of UWB, the pulses must be of low radio power, lesser than -42db for indoor applications which exhibits low electromagnetic radiations. In [21] discusses on two topologies for transceivers TX1 and TX2using different schemes for modulation used for achieving high data rate particularly for neural systems that are used for recording. It's designed using TSMC 0.18um CMOS Technology which aims at high data rate. In TX1 uses on-off keying and BPSK where as in TX2 is using ON OFF Keying modulation. TX2 architecture is designed for lesser power with improved topology design that benefits with consuming less area than the other design TX1, achieving same data rate. As well as reduced power by 30% in TX2. Also, an antenna both implantable as well as an external antenna are designed for transceivers.

Low processing energy consumed

Most of the UWB Applications are much concerned about processing energy because many devices are battery operated devices which must longer life. The system must work at extreme conditions as well as power control techniques to be included which increases the power efficiency. Hence this key feature for deployment of sensors in wireless sensor networks and Wireless Body area Networks where replacement of battery becomes costlier. As UWB Antennas are the most critical components of UWB medical systems [9]. Antennas for UWB can be classified into in body antennas whose purpose is investigate the interior body parts and antennas on body which are used to communicate between sensors on the different parts of the body Mainly for in body UWB application they are grouped in to different groups firstly, the antennas that are mounted directly on the body, which will be matched to the body directly or antennas that is immersed to match the medium that is air and the skin. The main goal is to reduce the reflection due to air and sinks dielectric. The second is the antenna directly mounted in the body. Thirdly for monitoring remotely.For [21] medical application such as brain or neural recording and simulating devices have been developed which interfaces with the brain machine interface. But it has certain drawbacks such as small size and low power consumption, while they are primarily benefited for support of high data rate which are primarily important for high density brain microprobes which is the key quality for reliable neural recording where multiple microelectrodes are interfaced together.

IV. CHALLENGES FOR UWB & SPECTRUM PROVISION IN INDIA

A. Challenges for UWB

The main Challenges of UWB is with the spectral provision allotment by FCC is not standardized; it's based on various countries for unlicensed users, which requires Global spectrum allocation. The Performance in terms of data rate, power consumption, co-existence with other wireless devices. Interference with other licensed bands is another challenge. Finally, Time-to-market considerations and Quality of service. Also achieving of high data rate following the power limits of FCC is challenging.

B. Spectrum provision in India

UWB Spectrum Provision in India: The following provision for UWB equipment may be considered its frequency band 6.0 – 7.25 GHz and EIRP density of -41 dBm/MHz is acquired according to the National Frequency Allocation Plan 2011 NFAP-2011

V. CONCLUSION

These paper discuses on the fundamental property of UWB signal as well as the technical approaches. A comparison of the wireless communication standards for indoor applications, its advantages over narrow Band is discussed. The UWB Application are classified based on the feature of UWB. Finally discusses on the challenges of UWB Design and the regulations set by governing bodies.

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