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# Ultra-Wideband Technology for Short-Range Communications

Woogeun Rhee, Xican Chen, Dang Liu, Fei Chen, and Zhihua Wang

Institute of Microelectronics, Tsinghua University
Beijing 100084, China
Email: wrhee@tsinghua.edu.cn

**Abstract**

**The interest in the ultra-wideband (UWB) technology as a potential wireless standard has been on the decline, but it could be retuned with the need of an ultra-low power low-cost transceiver system for wireless body area network (WBAN) and wireless sensor network (WSN) applications. Promising areas of the UWB applications lie in sub-nJ/bit transceivers, Gb/s proximity communications, low power sensor networks, and mobile healthcare systems. In this paper, a brief overview of the UWB technology and some useful features for next-generation short-range communication systems are discussed.**

## 1. Introduction

Since the ratification in 2002, the ultra-wideband (UWB) technology has not been widespread in the wireless market as challenged by other wireless standards such as the MIMO based WiFi. Especially, the WiMedia and Wireless USB solutions based on the MB-OFDM have not been successfully deployed due to high receiver complexity and regulatory issues [1]. On the other hand, the impulse UWB (IR-UWB) or other low complex UWB schemes exhibit unique characteristics that can differentiate it from existing standards. A need for the simple and energy-efficient wireless connectivity could make the UWB technology viable in the area of wireless body area networks (WBAN) and wireless sensor networks (WSN). In this paper, we review the UWB technology with the emphasis on short-range energy-efficient applications.

## 2. UWB Overview

For short-range low-cost UWB systems, we consider three UWB techniques; the IR-UWB, the frequency modulated UWB (FM-UWB), and the chirp UWB (C-UWB). The IR-UWB system transmits a train of short-duration pulses through an antenna, making it possible to achieve ultra-low power transmission with bit-level duty-cycled operation [2]. As an optional PHY of the IEEE 802.15.6 standard, the FM-UWB transceiver system features a constant envelope and a steep spectral roll-off of the transmitter output [3]. Different from the IR-UWB receiver, the FM-UWB receiver can perform FM demodulation without a local oscillator, and the complex carrier synchronization is not needed as in the case of the IR-UWB. However, the lack of duty-cycled operation makes it difficult for the FM-UWB transceiver to achieve ultra-low power performance. The C-UWB technique provides the duty-cycled operation with constant FM modulation [4]. Fig. 1 illustrates the comparison of the C-UWB with the IR-UWB and the FM-UWB.

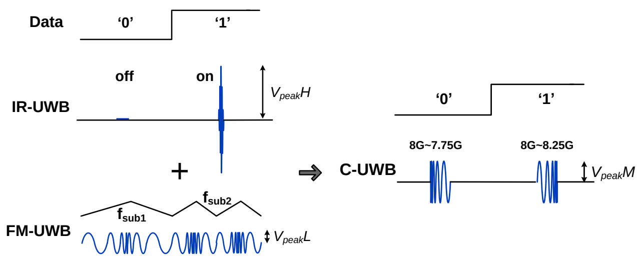


Fig. 1. Fractional-*N* PLL with hybrid FIR filtering.

The UWB system has shown promising features for short-range wireless applications because of high energy-efficiency, high range resolution, low radiated power, high penetration capability, and good multi-path fading resilience. In particular, high penetration capability and high precision ranging with a wide bandwidth of up to 7.5GHz (from 3.1GHz to 10.6GHz) make it easy to realize low-complexity high-resolution radar systems. Low electromagnetic radiation (<–41.3dBm/MHz) is safe for human tissue exposure and makes it suitable for medical applications.

## 3. UWB for Short-Range Communications

### *A. Mobile Healthcare*

For wireless medical applications, lossless connection with high security and noninvasive transmission are important factors. Moreover, in wireless medical video transmission systems such as portable ultrasound transducers [5], high data rate transmission with good energy efficiency is demanded to relax coding complexity and support a long battery lifetime.

Another fast growing area is in the wireless binaural hearing aid application. The ear-to-ear link enables signal processing of sound for both ears to improve the directivity and enhance speech intelligence, while the ear-to-device link provides an audio channel to commercial electronics such as smart TVs and smart phones. With advance CMOS technology, data converters and DSP blocks consume a small portion of the total power, and more than 70% of the whole power comes from the transceiver as illustrated in Fig. 2. To extend the battery lifetime for longer than a week,

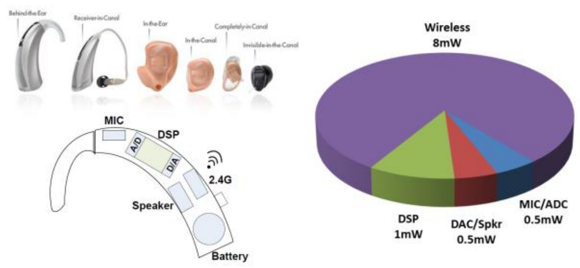


Fig. 2. Power consumption of wireless hearing aid devices.

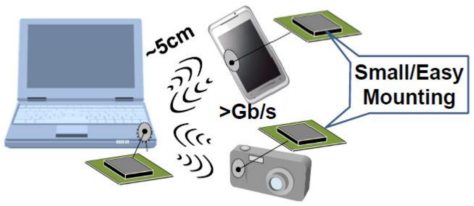


Fig. 3. Gb/s proximity transmission [6].

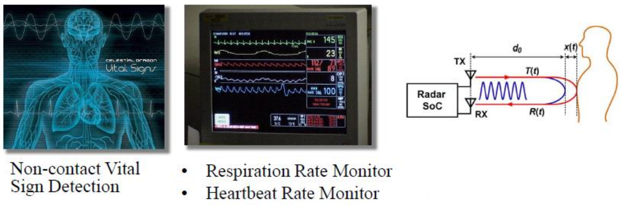


Fig. 4. Vital-sign detection radar system.

sub-mW power consumption is desired for the transceiver. Current transceivers based on the Bluetooth Low Energy (BLE) typically consumes >5mW, but a sub-mW transceiver is possible with the use of the C-UWB technique [4].

*B. Gb/s Proximity Data Transfer*

A mm-wave transceiver achieves a few Gb/s data transmission for cm-range proximity applications as depicted in Fig. 3 [6]. Even though the energy efficiency is good with the high data rate, the peak transceiver power typically exceeds 500mW, making the heating problem critical. To the contrary, the UWB based transceiver is shown to achieve <15mW for the data rate of 500Mb/s [7] and can achieve <40mW for Gb/s data transmission.

*C. Vital-Sign Detection Radar Systems*

Contactless monitoring of vital signs in the human body such as the respiratory rate monitoring is considered a single-target periodic tracking without the detection mode of the radar system. Due to fine ranging capability and low complex front-end design, the pulse based UWB radar has been proposed for low-cost human body monitoring systems as shown in Fig. 4. However, the pulse resolution must be in the order of pico-second to get a ranging resolution less than a millimeter, requiring an accurate timing control of the on-chip delay circuit. The ΔΣ time-to-digital converter (TDC) based ranging method is proposed for the UWB radar systems. In theory, a sub-mm ranging resolution is possible with the digital-intensive ΔΣ TDC based beamforming method [8].

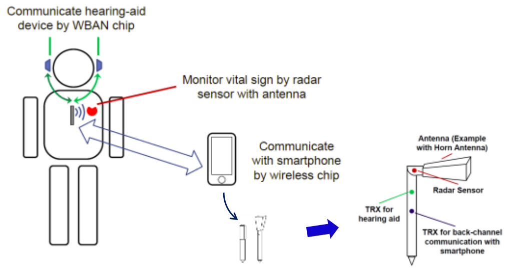


Fig. 5. Smart pen for mobile healthcare applications.

*D. Mobile Healthcare Applications*

The market for wireless health devices is set to expand enormously for the next decade as the new generation of wireless devices enables contactless health monitoring and remote diagnosis through online data. Fig. 5 shows an example of utilizing a smart pen which contains ultra-low power UWB transceivers and a high-resolution low-power UWB radar. With the small-size antenna, the ultra-low power consumption, and the highly-scalable data rate capability, the UWB technology is viable for next-generation smartphone systems.

## 4. Conclusions

The UWB technology is overviewed with focus on short-range communication systems. Having inherent features suitable for low-cost energy-efficient wireless connectivity, the UWB technology has high potential in the areas of sub-nJ/bit transceivers, Gb/s proximity communications, low power sensor networks, and mobile healthcare systems.

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