ULTRA WIDE BAND (UWB)

Embedded Systems Programming

N. Rushi (200601083)
Bhargav U. L. N (200601240)
OUTLINE:

What is UWB?

Why UWB?

Definition of UWB.

Architecture and Spectrum Distribution.

UWB vs Traditional narrow-Band

Advantages of UWB

Modulation Schemes

Trans-receiver Architecture.

Types of UWB Transmission.

Applications

Applications in Sensor Networks.
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WHAT IS UWB?

• Ultra wideband (UWB), is a wireless communication technology.

• Referred to as an impulse, baseband or zero-carrier technology, ultra-wideband systems operate coherently across a wide range of frequency spectrum relative to a center frequency.
WHAT IS UWB?

- A UWB signal can be typified by a series of low-power derivative-of-Gaussian pulses.
- Each pulse is extremely short in duration (10 to 1,000 picoseconds), typically much shorter than the interval corresponding to a single bit.
- The frequency spectrum of a UWB signal can be many gigahertz wide, overlaying the bands used by existing narrowband systems.
- UWB is also termed as a "zero carrier" radio. In other words, a UWB system can drive its antenna directly with a baseband signal.
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WHY UWB?

- Data rates in excess of 100 Mbit/s, while using a small amount of power and operating in the same bands as existing communications without producing significant interference.

- UWB is the leading technology for freeing people from wires, enabling wireless connection of multiple devices for transmission of video, audio and other high-bandwidth data.
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Definition of the UWB

- DARPA, coined the term UltraWideBand in the 1990s, and defined it as a system with a fractional bandwidth greater than 25 percent.
- Or, if it instantaneously occupies in excess of 1.5GHz of absolute bandwidth.

Fractional Bandwidth

\[ B_f = \frac{B}{F_c} = \frac{(F_h - F_l)}{(F_h + F_l)/2} \]
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FCC Spectrum Distribution
UWB Architecture

Various technology solutions running over the common platform

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UWB v/s TRADITIONAL NARROWBAND

- Rather than transmitting a continuous carrier wave modulated with information, a UWB radio transmits a series of very narrow impulses.

- It does not require a Sine-Wave RF carrier.
A COMPARISON OF WAVEFORMS

TRADITIONAL NARROWBAND

ULTRA-WIDE BAND IMPULSE

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Throughput v/s Distance
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ADVANTAGES OF UWB

• High data rate – because of high frequency pulses
• High Capacity – enables it to achieve high throughput and greater spectrum sharing
• Low power – Currently it uses as low as -41.3 dBm
• Simple RF circuits – no need for mixers. This directly translates to low cost
Data Rate Comparisons

R: Ultra-WideBand Technology for short or medium range wireless communications, Intel Architecture Labs
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High Performance: Shannon’s Law

Shannon’s equation shows that increasing channel capacity requires linear increases in Bandwidth while similar channel capacity increases would require exponential increases in power. This is why UWB technology is capable of transmitting very high data rates using very low power.

\[ C = B \log_2 \left(1 + \frac{S}{N}\right) \]

Shannon’s capacity limit equation shows capacity increasing as a function of BW (bandwidth) faster than as a function of SNR (signal to noise ratio).
Advantages of UWB

- **Accurate delay estimates** – because of high frequency pulses, it is possible to provide position accuracy within a few centimeters

- **Robustness to fading** - Wideband nature of the signal reduces time varying amplitude fluctuations

- **Flexibility** – Can trade throughput for distance, thus useful for a number of applications
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Modulation Schemes

Pulse amplitude modulation (PAM) :

- The length of the pulse denotes the character.
- For example, a longer pulse denotes a 1 and a shorter pulse denotes a 0.
- M-ary PAM is also possible depending on the length of the pulses.
- It gives very poor energy efficiency.

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Modulation Schemes

On-Off keying (OOK):

- The presence of a pulse is denoted by 1 and the absence of a pulse is denoted by 0
- It has a simple implementation but poor energy efficiency

Data: 1 0 0 1

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Modulation Schemes

Pulse Position Modulation (PPM):

- A “1” or a “0” is determined by different picoseconds delay (say T1 and T2)
- M-ary PPM is also possible
- Time-hopping (shifting each pulse’s time position, in accordance with a code) is also possible with PPM

Data: 01

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UWB Trans-Receiver architecture

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TYPES OF UWB TRANSMISSION

There are two forms of UWB Transmission :-

• Impulse Radio (IR-UWB)

• Multi-band UWB
IMPULSE RADIO (IR-UWB)

- This is a more conventional approach to UWB transmission.

- Uses extremely short pulses with duration of the order of nanoseconds to transmit information.

- Short pulses have very large bandwidth of the order of a few GHz.
MULTIBAND UWB

• Instead of using the entire band to transmit information, the spectrum can be divided into several sub-bands (of e.g. 500 MHz each).

• Data can be transmitted concurrently.

Figure 2. The MultiBand OFDM frequency band plan.

R: http://www.deviceforge.com/articles/AT8171287040.html
DESIGN CONSIDERATIONS OF A RECEIVER

- Link Budget Analysis
  - Link budget analysis is dependent on following key parameters:
    - receiver thermal noise
    - noise figure
    - sensitivity and dynamic range
    - receiver gain.

- Propagation Effects
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UWB Applications in Sensor Networks and Embedded Systems.

- Major application areas:
  - Communications
    - Wireless Audio, Data & Video Distribution
    - RF Tagging & Identification
  - Radar
    - Collision/Obstacle Avoidance
    - Precision Altimetry
    - Intrusion Detection (“see through wall”)
    - Ground Penetrating Radar
  - Precision Geolocation
    - Asset Tracking
    - Personnel localization
The cars have UWB sensors on their license plates which communicate with other cars in order to avoid collisions.
Fire Rescue Operations

UWB Devices (receivers) could be placed outside the affected building or on the ladder (generally). The firefighters carry a small UWB transmitter on their chest (refer picture) which transmits information on the whereabouts of the person to the device outside the building.

UWB’s ability to see through concrete structures and buildings is a boon to any search operations.
Digital Home
Conclusion
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‘of Btech 2005.
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THANK YOU.