Introduction to UWB systems

Summary

• Introduction to unlicensed spectrum and UWB
• Examples of UWB systems
• Application examples
Tendency to allocate more unlicensed spectrum

- UWB is about low power transmission and non-harmful co-existence with other services
- Unlicensed use sharing licensed spectrum
  - Radio systems are smarter than 70 years ago
  - Spectrum management based on old assumptions
- Future UWB systems will be different from systems analyzed before rulemaking
- UWB spectrum characteristics allow
  - high bit rate, short range (MBOA)
  - low power, location awareness (IEEE 802.15.4a)

ISM: Industrial, Scientific, Medical
U-NII: Universal National Information Infrastructure
MBOA: Multiband OFDM Alliance
UWB: Ultra-wideband

The cost of licensed spectrum halves every six months

Spectrum Auctions
1994: 500kHz at $213M
Interactive Video and Data Services
2000: 12MHz at $1.2M
Broadcast Auction
**FCC spectrum mask**

Same limit of unintentional radiator allowed by part 15 for EMI

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**Initial Results: Ambient Noise**

Office Space

This plot depicts measured emissions in the GPS L1 frequency band (1575.42 ± 12 MHz) in the work area of a business that utilizes a large number of personal computers in an open area. Measurements made at FCC Laboratory in Columbia, MD, August 2002.

Source: Ed Thomas, FCC, 2003
Interference to existing signals

- We detected no changes in the spectrum, video quality, $E_b/N_0$, or pre-Viterbi BER of the FSS downlink signal when the UWB transmitter was turned on.

[Source: Infocomm Development Authority of Singapore (IDA), June 2004]

“Results have shown levels of interference similar to what is already allowed by the rules.”

[Source: MBOA, January 2004]

Example of Single Band UWB

$\text{BW}_{-10\text{dB}} = 7.26$ GHz

$ST\ Micro: \text{doc.: IEEE 802.15-03/139r3}$
DS-UWB

- Coded short duration pulses spread the signal energy over frequency and time
- Can overlay existing FCC frequency assignments
  - Spread is so broad, little energy gets in a narrowband
  - Short range WPAN systems can operate below the detection threshold of conventional receivers
- Low probability of intercept (LPI) Bi-Phase not spikey in time or frequency domains

Spectral Keying™ Modulation

- Transmit 2 or more subpulses using different bands
- Order of bands defines symbol
Example of multiband UWB: OFDM

![Graph showing time-frequency allocation for multiband UWB OFDM]

- **Guard Interval for TX/RX Switching Time:** 9.5 ns
- **Cyclic Prefix:** 60.6 ns

Source: Infocomm Development Authority of Singapore (IDA)

Credits: TI TG3a proposal

MBOA(*) specification summary

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- **Mandatory:** 3432 MHz, 3960 MHz, 4488 MHz, 5016 MHz, 5544 MHz, 6072 MHz, 6600 MHz, 7128 MHz, 7656 MHz, 8184 MHz, 8712 MHz, 9240 MHz, 9768 MHz, 10296 MHz
- **Optional:** 10298 MHz
- **Link Margin Ref. (0 dB):**
  - Band #1: -0.27 dB
  - Band #2: -0.49 dB
  - Band #3: -0.65 dB

Global Solution: Flexible band plan and use of OFDM subcarriers allows for “spectrum shaping” which can be used to meet worldwide regulatory requirements

(*) www.multibandofdm.org

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RF CMOS for UWB

Using appropriate design techniques and optimizations an ultrawideband multiband-OFDM analog front end can be implemented in low-cost standard CMOS.

Standard CMOS Ultrawideband Single-Chip Solutions

By Dan Meacham and Krishnamurthy Soumyanath

EE Times
May 17, 2004

Main interest in two areas

Throughput capacity, Mb/s

Indoor range, m

0 10 20 30 40 50 60 70 80 90 100

0.10 1 10 100 1000

UWB

802.11a

802.11b

802.15.4
Many stars need to be aligned

Promoter's Group
- Intel
- Microsoft
- NTT
- Philips
- Samsung

Key Contributors Group:
- Agere
- Broadcom
- CSR
- Lucent
- Marvell
- STMicro

Industry timeline for WUSB

- 9/1/04: Start
- 8/1/04: Spec 0.8
- 10/1/04: Spec 0.9
- 4/1/05: Spec 1.0
- 4/1/05: End - Products prototypes
- 10/1/05: End - Products on shelves
- 7/1/05: Start product certification
- 1/1/05: Silicon engineering samples

You Are Here
**High bit rate applications**

- **Supported data Rates**: 110, 200, 480 Mbps
- **Range**: 10m, 4m, 4m
- **Power**: 100mW, 250mW

**Value Proposition**: Hundreds of Mbps operating at low power and provided at low cost, enabling wireless multimedia and high-speed cable replacement.

**Conclusions**

- Opportunity for spectrum sharing
- High performance, low cost systems are feasible
- Commercial opportunity for high bit rate applications
- Strong industry support worldwide