TCB Workshop

Ultra-Wideband (UWB)

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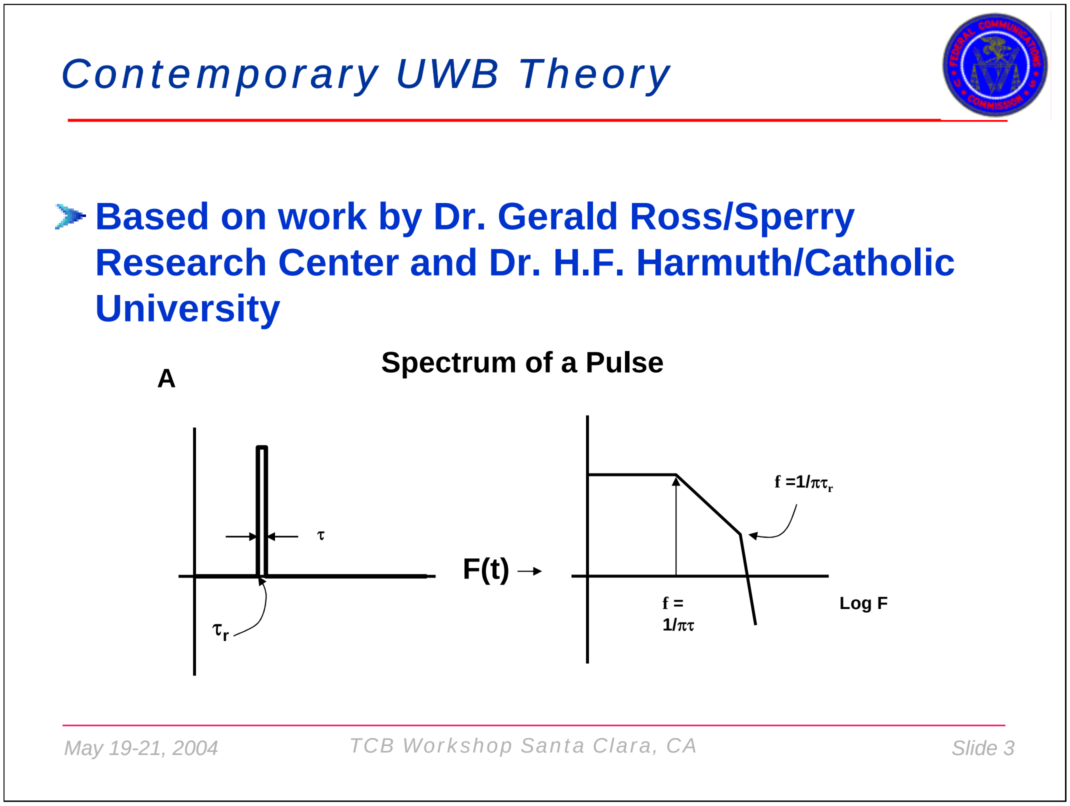
What is UWB?

- **Wireless communication or remote sensing using non-sinusoidal or limited cycle sinusoidal carriers**
- **UWB signals are typically produced by applying an impulse, mono-cycle, or step signal to a resonant antenna**
- **In the frequency domain, a very (ultra) wide spectrum signature is created.**



Spark Gap Transmitters

Early UWB history dates to birth of radio

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History dates back to spark gap transmitters generating impulse excitation of an antenna, producing an UWB-like spectra.

UWB Signal Generation

- **Waveforms generated by edge of very fast rise-time pulse**
- **Impulse obtained from first derivative of step rise-time**
- **Monocycle obtained from first derivative of the impulse (or second derivative of step rise-time)**
- **Resulting narrow pulse used to "shock excite" a resonant antenna**
  - Properly designed antenna can function as band-pass filter, limiting the resultant spectra

UWB Modulation Schemes

- **Pulse Position Modulation (PPM)**
  - Position of pulse (in time) determines the binary state (0 or 1)
- **Pulse Amplitude Modulation (PAM)**
  - Pulse amplitude level determines binary state
- **On-Off Keying (OOK)**
  - Binary state determined by presence or absence of a pulse
- **Binary Phase Shift Keying (BPSK)**
  - State is represented by change in signal phase

UWB Communications Potential

- **Shannon-Hartley theorem states that channel capacity:**
  - Grows linearly with bandwidth
  - Decreases logarithmically as SNR decreases
- **UWB signals possess fine time resolution making it possible to finely resolve multi-path components**
- **Potential exists for UWB devices to provide high data rate, short range communications in extreme propagation environments (e.g., indoors)**

Anticipated UWB Applications

- **High-speed mobile local area networks (LANs)**
- **Wireless personal area networks (WPANs)**
- **Imaging systems (ground penetrating and through-wall radar, medical imaging)**
- **Electronic surveillance and detection**
- **Secure communications**
- **Personnel and asset tracking**
- **Automotive radar (anti-collision) and sensors**

Potential Strengths Associated with UWB Technology

- **Low Cost**
  - Utilizes baseband radio architecture implemented in CMOS
- **Low Power Consumption**
  - Low transmit duty cycles
- **High Capacity**
  - Large bandwidth
- **Multipath Robust**
  - Frequency diversity

Potential Weakness Associated with UWB Technology

- **Compatibility of UWB receivers in "real world" electromagnetic environment is unknown**
  - Since UWB authorized as an unlicensed service, interference protection not provided or considered
- **Limited studies of interference potential to UWB receivers**
  - Particularly from high power emitters (e.g., radar, PCS and cellular, paging, etc)
  - Mitigation possible through careful frequency band selection

UWB Regulatory History

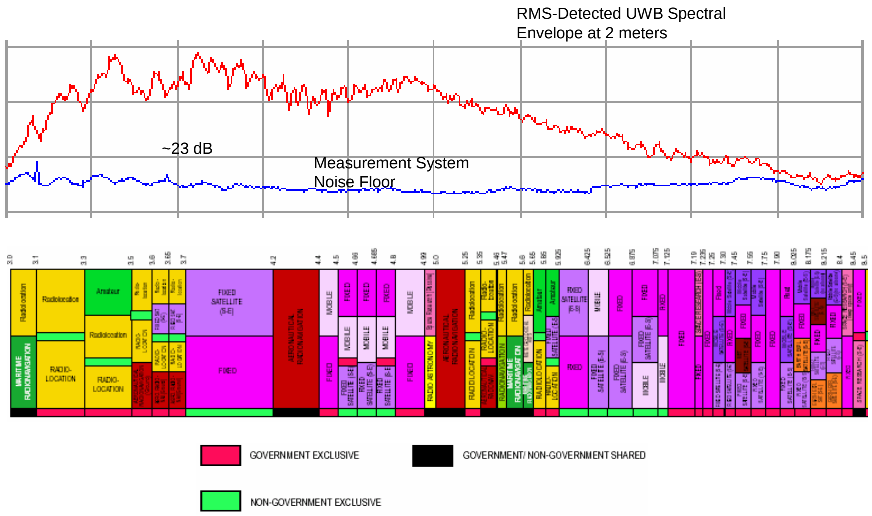
- **Application for waivers received from four UWB manufacturers in 1998**
- **NOI issued in Sept, 1998**
- **NPRM released in May, 2000**
- **First R&O adopted in Feb, 2002**
- **MO&O and Further NPRM released in Feb, 2003**

Primary Spectrum Issues

- **UWB communications require access to large swaths of radio spectrum**
- **UWB emissions incompatible with existing spectrum management protocol**
- **Spectrum identified for UWB operation will necessitate access to “restricted bands”**
  - Restricted bands typically reserved for Safety-of-Life, National Security and/or Scientific Research operations
- **Requires operation in spectrum long used by incumbent licensees, often on a sole basis**

UWB Spectral Envelope

(Not to Scale – For Example Only)



First UWB R&O

- **Established an emission definition applicable to UWB communications**
  - BW (-10 dB) > 500 MHz, or
  - Fractional BW > 0.2
- **Authorized limited, low-power UWB commercial applications**
  - Imaging (GPR, TTWR, Medical)
  - Short-range communications systems (Indoor/Outdoor)
  - Field disturbance sensors (security systems)
  - Short-range automotive radar and sensors

UWB Emission Masks

- **Independent emission masks adopted for each authorized UWB application**
  - Based on extensive interference analyses, measurements and estimated proliferation potential
  - Reflect importance of sensitive portions of the spectrum (e.g., 960-3100 MHz)
  - Coordinated extensively with DoD, NTIA and other Government Agencies

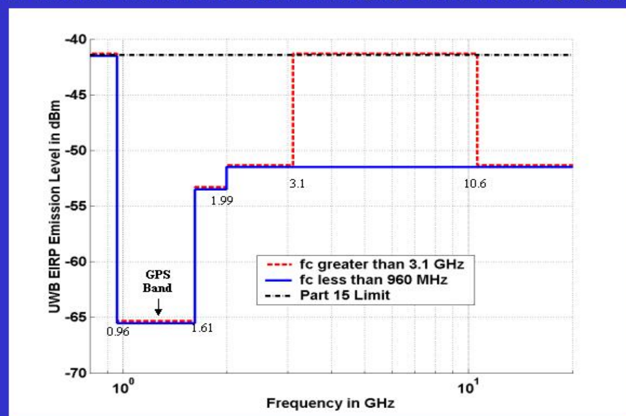
Authorized UWB Operating Bands

- **Imaging Systems**
  - < 960 MHz
- **Communications and Field Disturbance Sensors**
  - 3.1-10.6 GHz
- **Short Range Vehicular Radar**
  - 22-29 GHz
- **960-3100 MHz range protected**
  - including GPS L1, L2, and L5 bands

UWB Imaging Emissions Mask

Preliminary

UWB Emission Limits for GPRs, Wall Imaging, & Medical Imaging Systems



Operation is limited to law enforcement, fire and rescue organizations, scientific research institutions, commercial mining companies, and construction companies.

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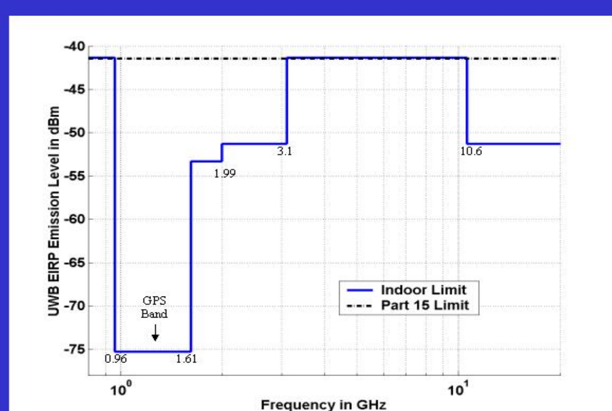
UWB Indoor Emissions Mask

Preliminary

UWB Emission Limit for Indoor Systems



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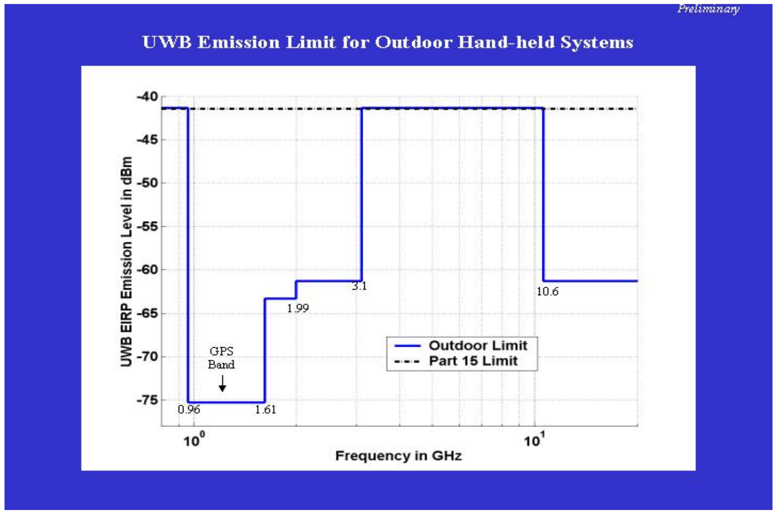
UWB Outdoor Emissions Mask



Current State of UWB Technology (Commercial Systems)

- **FCC has issued few unlicensed grants for UWB devices**
  - Most have been for GPRs
- **IEEE 802.15.3a task group developing UWB communications performance standards**
  - Adoption of a standard likely to be followed by increase in UWB application submissions

FCC Laboratory UWB Activities

- **Developing compliance measurement procedures for certification of UWB devices**
- **Performing RF characterization of all devices submitted under UWB rules**
- **Continuing analytical and experimental assessment of UWB interference potential**
- **Monitoring UWB industry developments**

Interpretations Data Base

- **UWB Equipment Frequently Asked Questions**
  - http://hraunfoss.fcc.gov/eas_public/SilverStream/Pages/pg_html_fts_res.html?letter=1320
- **How are RMS measurements for Ultra wide band (UWB) devices made**
  - http://hraunfoss.fcc.gov/eas_public/SilverStream/Pages/pg_html_fts_res.html?letter=1364

RMS measurements for UWB devices

Website:
http://hraunfoss.fcc.gov/eas_public/SilverStream/Pages/Fpg_html_fts_res.html?letter=1364

- **The first option is to use an analyzer that incorporates an RMS detector. Check analyzer specifications.**
- **Set integration time properly.**
  - In order to obtain the maximum 1 millisecond (mS) integration time, the ((sweep time) / number of bins), should be less than or equal to 1 mS. The default number of bins(also referred to as points) on some analyzers is 601 points (pts).
  - Do not use trace averaging or average detector.
- **Alternatively**
  - When an analyzer does not incorporate a true RMS detector, there is also a method described in Appendix F, paragraph (3) in the First Report and Order (FCC 02-48)
    - Detailed in the interpretation letter at the above website.
    - When obtaining RMS values in either manner, describe and/or provide the formula used to post-process the data with the Certification filing.