USB 3.0: Facing the Challenges of SuperSpeed USB Product Development

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Agilent Technologies

Presentation Goals

• Help you understand market need for USB 3.0

• Provide progress update and schedule of development activities

• Provide high level overview of USB 3.0 architecture

• Compare and contrast to USB 2.0: what has changed and what is the same

• Disclaimer: The material and content that describes specific details of the USB 3.0 specification belongs to the USB 3.0 Promoters. Agilent is not speaking or presenting on behalf of the USB 3.0 Promoters.
USB/WUSB Test

**Agenda**

USB Market Overview
Physical Layer Overview
Cable/Connector challenges
Hubs
Frequently Asked Questions
Summary

**Background**

Hi-Speed USB (480 Mbps) is adequate for many products
Emerging applications will benefit from higher performance

Most other aspects of SuperSpeed USB will remain the same:
- Backward compatibility with USB 2.0
- Maintain the extensive device driver infrastructure
- Preserve USB ease of use expectations for Users

One of the biggest challenges of USB 3.0 Will be following the amazing USB success
**USB 2.0 is now a performance bottleneck**

High speed USB 2.0 = 480 Mbps signaling rate
- Real throughput is typically much less at around ½ this data rate (< 240Mbps)
- Additional limitations due to IO performance limitations
- Approximately 35 MB/s maximum usable application data rate

Something faster is needed for large digital multi-media files

<table>
<thead>
<tr>
<th></th>
<th>Song / Pic</th>
<th>256 Flash</th>
<th>USB Flash</th>
<th>SD-Movie</th>
<th>USB Flash</th>
<th>HD-Movie</th>
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<tbody>
<tr>
<td>4 MB</td>
<td>5.3 sec</td>
<td>5.7 min</td>
<td>22 min</td>
<td>2.2 hr</td>
<td>5.9 hr</td>
<td>9.3 hr</td>
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<tr>
<td>USB 1.0</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>USB 2.0</td>
<td>0.1 sec</td>
<td>8.5 sec</td>
<td>33 sec</td>
<td>3.3 min</td>
<td>8.9 min</td>
<td>13.9 min</td>
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<tr>
<td>USB 3.0</td>
<td>0.01 sec</td>
<td>0.8 sec</td>
<td>3.3 sec</td>
<td>20 sec</td>
<td>53.3 sec</td>
<td>70 sec</td>
</tr>
</tbody>
</table>

**SuperSpeed USB Applications**

Solid State/Flash Storage Market in 2010
Market Requirements Summary

• Performance 10X USB2 - PHY signal rate of 5 Gbps
  – data throughput > 200 MB/s
• Optimize for power efficiency
• Connector & Cable backward compatible with USB 2.0
• Protocol scalable to provide extension beyond 5Gbps
• Minimize SW impact
  – Same Programming and Device models as USB 2.0
• Support Virtualization for Devices

SuperSpeed USB Timeline

STDs Development
Product Development
Initial Deployment
Broad Deployment

USB 3.0 Specification Complete
Compliance Program/Industry Enabling Development
USB 3.0 Developers Conference

2008 | 2009 | 2010 | 2011
USB 3.0 Industry Events Update

• USB 3.0 Promoter and Contributor Groups formed in 2007
• Industry review and Intel Developer Forum updates provided further information in first quarter of this year
• USB 3.0 Adopter participation begins when final spec is released in 2H’08
  • Joined by Adopter Agreement
• Compliance test requirements and enabling work beginning in July
• USB-IF will continue to manage Logos, test events and marketing/promotion
• USB 3.0 specification Rev 0.9 available to contributors.
• IDF demo of USB 3.0 cables and 5Gbps USB3.0 test chip
• IDF announcement of USB 3.0 developers conference in November timeframe.

http://www.usb.org/usb30

What is different for USB 3.0

• USB 2.0 High-Speed
  ✓ 480Mbps
  ✓ NRZI, Half Duplex
    (1 bi-directional link)
  ✓ 4 signals
    Dp, Dm
    VCC, GND
  ✓ Cable Lmax= 5meter
  ✓ IconfigLP/FP = 100mA/500mA
  ✓ No SSC

• USB 3.0 SuperSpeed
  ✓ 5 Gbps
  ✓ 8B/10B PRBS, Full Simplex
    (2 uni-directional links)
  ✓ 8 signals
    4 USB2
    4 SS Signals
  ✓ Cable Lmax = Spec Detail
  ✓ IconfigLP/FP = Spec Detail
  ✓ SSC
SuperSpeed Measurement Requirements

• Compliance Testing:
  Still being defined - will reflect many of the same requirements as PCI Express 2.0 (5GT/s) and SATA compliance testing

✓ Compliance will be measured at the end of the “compliance channel”
✓ SMA termination for TX signals, phase matched SMA cable
✓ Terminate link under test with high speed oscilloscope
✓ Measure transmitted waveform with high speed oscilloscope
✓ Use compliance pattern
✓ 1M UI of data
✓ Compute:
  ✓ eye diagram,
  ✓ Rj, Dj, Tj@10^-12 BER,
  ✓ average data rate,
  ✓ rise/fall time.

Achieve Success at 5GT/s with Good designs and Agilent Tools

• Cable, connector and channel characterization and testing will be crucial to ensuring links are reliable and meet performance requirements
  • TDR/TDT measurements will be essential to ensuring designs meet differential impedance targets
  • VNA measurements will allow verification of return loss, insertion loss and near/far end cross talk requirements

• Those same S-parameter measurements will allow de-embed of fixture and cabling to characterized your transmitter design to package/die.

• Signal BW and channel length will result in closed eye measurements

  Equalization will also be needed to open eye at RX
Cable and Connector Challenges

- Deliver low cost
- Backward compatibility with USB 2.0
- Minimize connector types
- Meet performance reqts for 5Gbps
- Ease of use
- EMI/ESD

Link Layer Improvements

- Bus turnaround times require 100s of bit times
- Full Simplex bus topology greatly improves bus utilization
Frequently Asked Questions

1. Does USB 3.0 define or require an optical connection?
   • NO, this was discussed during the initial phases of the investigation but was ruled out due to cost. USB 3.0 will be wired only.

2. Is USB 3.0 going to be backward compatible with USB 2.0?
   • Yes, USB 3.0 requires that the host port is compatible with all USB 2.0 supported speeds: Low speed, Full speed and High speed.

3. Why does SuperSpeed require 4 new signals, SSTXP, SSTXN, SSRXP, SSRXN?
   • Backwards compatibility requires support for Low and Full-Speed USB. These run at 3.3V signal levels which is not compatible with IO buffers designed to run at 5Gbps

4. How will users know that a USB port supports SuperSpeed?
   • USB 3.0 ports will be color-coded Blue to make them recognizable.
Summary

SuperSpeed USB addresses USB 2.0 performance bottleneck and retains attributes that made USB so successful

• Maintains backward compatibility
• 10x performance
• Same programming and device models as USB 2.0
• Optimized for power efficiency
• Protocol scalable to 20Gb/s

USB 3.0 will deliver Performance and Power Efficiency
Agilent has the tools and expertise to help you validate your designs
**Ultrawideband Technology**

- **UWB**
  - Direct Spectrum
  - IEEE
  - MB-OFDM
  - RADAR
  - Communications
  - WiMedia
  - Extensions
  - Bluetooth
  - **Certified Wireless USB** (USB-IF)

- **Certified Wireless USB, based on WiMedia, MB-OFDM, UWB**

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**Connecting the last 5 meters**

- **Certified High Speed USB**
  - Most successful interface standard, about 3 billion ports
  - 480 MBit data rates

- **Certified Wireless USB**
  - High speed USB replacement (480 MBit/s), Any other questions?
  - Based on WiMedia Alliance OFDM UWB Technology
  - Not just wireless USB (low speed mice and keyboards)
  - Low power, short range, high data rates

- **Bluetooth**
  - Headsets and automotive the current “killer” applications (1 MBit/s)
  - Bluetooth now planning to use WiMedia UWB for higher data rates
  - Years away
WiMedia UWB Platform

Companies Driving the Industry
WiMedia Promoters
- Intel, HP, Kodak, Samsung, Sony, Microsoft
First Silicon Chip Providers
- Alereon, Realtek, Staccato, Tzero, Wisair, Focus Enhancement
USB Industry Forum (Certified Wireless USB)
- NEC, PHILIPS (NXP), Lucid Port, Microsoft, HP, Synopsis,
Leading Consumer Product Manufactures
- Listed WiMedia members
All current portable products with USB ports, a high percentage will consider Certified Wireless USB
Short Range Wireless enabled by UWB


PCs and Peripherals

External Hard Drives, CD/DVD, burners

Printers

MP3

Digital Cameras

Why is Ultra Wideband so special?

UWB is sometimes called an underlay technology, because it can transmit in the “noise floor” of narrow band signals. More BW translates to higher data rates even with simple modulation techniques.
### UWB Bands and WW Regulations

**Worldwide Regulatory Status**

<table>
<thead>
<tr>
<th>Band Group</th>
<th>Band Group</th>
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<th>Band Group</th>
<th>Band Group</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>#2</td>
<td>#3</td>
<td>#4</td>
<td>#5</td>
<td>#6</td>
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<tr>
<td>US</td>
<td>EU</td>
<td>Japan</td>
<td>Korea</td>
<td>China</td>
<td>proposed</td>
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</table>

- **Usable bands** (No protection requirements)
- **Usable bands** (with protection requirements)
- **Unusable bands**

<table>
<thead>
<tr>
<th>Carrier Frequency</th>
<th>3432 MHz</th>
<th>3980 MHz</th>
<th>4016 MHz</th>
<th>5044 MHz</th>
<th>5072 MHz</th>
<th>6000 MHz</th>
<th>7028 MHz</th>
<th>7064 MHz</th>
<th>8184 MHz</th>
<th>8212 MHz</th>
<th>9152 MHz</th>
<th>9280 MHz</th>
<th>9308 MHz</th>
<th>10306 MHz</th>
<th>10334 MHz</th>
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<tbody>
<tr>
<td><strong>Symbol (312.5ns)</strong></td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
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<td>37</td>
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<tr>
<td><strong>165NSYM</strong> Total number of samples per symbol</td>
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<td><strong>3.2 MHz</strong> Symbol Rate</td>
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<tr>
<td><strong>0x0</strong> Frame/PLCP Preamble</td>
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<td><strong>0x0</strong> PLCP Header</td>
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<tr>
<td><strong>0x0</strong> Channel Estimation Sequence</td>
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</tbody>
</table>

### WiMedia PHY: Time Domain

#### Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol Rate</td>
<td>FSYM</td>
<td>3.2 MHz</td>
</tr>
<tr>
<td>Symbol Interval</td>
<td>TSYM</td>
<td>312.5 ns</td>
</tr>
<tr>
<td>FFT and FFT period</td>
<td>TFFT</td>
<td>242.42 ns</td>
</tr>
<tr>
<td>Zero-padded suffix duration in time</td>
<td>TZPS</td>
<td>70.08 ns</td>
</tr>
<tr>
<td>Sampling Frequency</td>
<td>Fs</td>
<td>528 MHz</td>
</tr>
<tr>
<td>Total number of subcarriers (FFT size)</td>
<td>NFFT</td>
<td>128</td>
</tr>
<tr>
<td>Number of samples in zero-padded suffix</td>
<td>NZPS</td>
<td>37</td>
</tr>
<tr>
<td>Total number of samples per symbol</td>
<td>NSYM</td>
<td>165</td>
</tr>
</tbody>
</table>
**WiMedia PHY: Frequency Domain**

FCC, Unlicensed 3100 MHz – 10600 MHz, -41.3 dBm/1 MHz

528 MHz x 14 Bands

![Diagram of frequency domain](image)

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Frequency</td>
<td>Fs</td>
<td>528 MHz</td>
</tr>
<tr>
<td>Total number of subcarriers</td>
<td>NFFT</td>
<td>128</td>
</tr>
<tr>
<td>Number of data subcarriers</td>
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<td>128</td>
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<tr>
<td>Number of pilot subcarriers</td>
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<td>12</td>
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<tr>
<td>Number of guard subcarriers</td>
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<td>10</td>
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<tr>
<td>Subcarrier Frequency Spacing</td>
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<td>4.125 MHz</td>
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</table>

**WiMedia PHY: Time and Freq.**

<table>
<thead>
<tr>
<th>TFC Number</th>
<th>Band ID (Band number) for TFC</th>
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<tbody>
<tr>
<td>1</td>
<td>1 2 3 1 2 3 1 2 3</td>
</tr>
<tr>
<td>2</td>
<td>1 3 2 1 3 2 1 3 2</td>
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<tr>
<td>3</td>
<td>1 1 2 2 3 3 2 2 3</td>
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<td>4</td>
<td>1 1 1 1 1 1 1 1 1</td>
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<tr>
<td>5</td>
<td>2 2 2 2 2 2 2 2 2</td>
</tr>
<tr>
<td>6</td>
<td>3 3 3 3 3 3 3 3 3</td>
</tr>
</tbody>
</table>

**Frequency-Domain Spreading**
- Transmit same information
- Spreading factor is 2
- Data A = Data B but over the different sub-bands.

**Time-Domain Spreading**
- Transmit same information over two symbols in TFI mode.
- TFI: Time-Frequency Interleaving
- FFI: Fixed Frequency Interleaving
OFDM with Frequency Switching

TFC1 (Band Group 1) Frequency switch (3.1-4.9 GHz)

<table>
<thead>
<tr>
<th>Time</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>528 MHz</td>
<td>3960 MHz</td>
</tr>
<tr>
<td>128 subcarriers</td>
<td></td>
</tr>
<tr>
<td>3432 MHz</td>
<td></td>
</tr>
<tr>
<td>3960 MHz</td>
<td></td>
</tr>
<tr>
<td>4488 MHz</td>
<td></td>
</tr>
<tr>
<td>sym 312.5 ns</td>
<td></td>
</tr>
<tr>
<td>3432 MHz</td>
<td></td>
</tr>
<tr>
<td>3960 MHz</td>
<td></td>
</tr>
<tr>
<td>4488 MHz</td>
<td></td>
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<tr>
<td>3432 MHz</td>
<td></td>
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<tr>
<td>3960 MHz</td>
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<td>4488 MHz</td>
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<td>3432 MHz</td>
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<td>3960 MHz</td>
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</tr>
<tr>
<td>4488 MHz</td>
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</tr>
</tbody>
</table>

WiMedia RF Measurement Solution

**Agilent Transmitter**

“Golden Radio”

- Agilent N7619A Signal Studio for Multiband OFDM UWB
- Analogue IQ
- Agilent E8267D PSG Series Vector Signal Generator
- UWB Signal Creation
- Agilent N6030A Arbitrary Waveform Generator
- Advanced Design System
- Regulatory Test, FCC
- Ship date 9/15/06

**Agilent Receiver**

- Custom components on UWB Library support WiMedia Today
- WiMedia Compliant Library
- Ship date 9/15/06
- New!! Version 9.0. Available NOW
- Agilent E4440A PSA Series 26.5GHz Spectrum Analyzer
- Agilent E4440A VSA Software
- Agilent 89601A VISA Software
- UWB Signal Verification, EVM measurement
- Available NOW
RF tests for WiMedia based radios

Example PHY Compliance Tests
- Transmit Center Frequency
- Transmit Power Control
- Power Spectral Density Mask
- Adjacent Channel Power Ratio (ACPR)
- Error Vector Magnitude (EVM)
- Receiver Power Sensitivity
- Receiver Frequency Offset Sensitivity

Radio Quality Measurements

Random Noise

Phase Noise

AM/AM Distortion

AM/PM Distortion

Delay Distortion/ISI

Interference

Constellation Diagram
Agilent Transceiver Test Setup

WiMedia UWB Demodulation with 89601A
Summary

• Certified Wireless USB is next mainstream standard for wireless connectivity.
• Certified Wireless USB is based on WiMedia PHY technology.
• Agilent builds Certified Wireless USB tests from years of RF measurement experience.
• Agilent solution provides a full test/analysis environment for PHY measurements on Certified Wireless USB transceivers.
• Agilent, Contributor member of WiMedia, USB-IF and Certified Wireless USB
• Agilent Provides “Gold Suite” testing at all USB-IF workshops.
Further Information

Ultra-Wideband Communication RF Measurements Application Note AN1488 5989-0506EN


IEEE 802.15.3 Home Page http://www.ieee802.org/15/

Agilent Application Note 1380-1 “RF Testing of Wireless LAN Products”

Agilent Application Note “Agilent PSA Series Swept and FFT Analysis”

www.agilent.com/find/uwb
www.wimedia.org
www.usb.org/wusb/home