LabVIEW User Group Meeting

Long Island Chapter
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USB Data Acquisition with LabVIEW

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National Instruments
USB Data Acquisition
USB for Data Acquisition

- Hi-Speed bandwidth makes waveform transfer more feasible
- External components for easy hardware setup and rental PC restriction avoidance
- Easiest device detection of any bus
USB Specification

- Designed to help standardize consumer PC products
- **Ease of use** was a top design criteria
- USB 2.0 standardized at the end of 2001
  - Needed for higher-bandwidth devices
USB Ease of Use with NI CompactDAQ

DEMO
Compatibility

• USB devices are backward compatible
• Hi-Speed devices can operate in a low-speed hub at low speed
• Hub performance with multiple devices varies by manufacturer and design
### Full-Speed versus Hi-Speed

Bandwidth is independent of specification version.

**Not all USB 2.0 devices are Hi-Speed.**

<table>
<thead>
<tr>
<th>Speed Rating</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Speed</td>
<td>1.5 Mb/s</td>
</tr>
<tr>
<td>Full-Speed</td>
<td>12 Mb/s</td>
</tr>
<tr>
<td>Hi-Speed</td>
<td>480 Mb/s (60 MB/s)</td>
</tr>
</tbody>
</table>

Look for speed rating.
Available Bandwidth

- Each Hi-Speed root hub has an available 60 MB/s
- Most PCs have 1 or 2 Hi-Speed root hubs
- All connected devices share root hub bandwidth

Look for the word “enhanced” in Windows device manager.

[Image of Device Manager window with highlighted entries]
Different Buses for Different Requirements

- **USB**
  - Easiest setup and user experience
  - No internal PC installation
  - Almost 5X faster than LAN

- **Ethernet**
  - Over great distance
  - Many users for one network device

- **PCI/PXI Express**
  - Highest throughput to PC memory
  - Best synchronization
  - Widest array of measurement modules
Rapid Evolution of PC Bus Technology

- USB
- Ethernet
- PC Buses

- ISA
- 10 Mbit Ethernet
- 100 Mbit Ethernet
- USB 1.1
- PCI 32/33
- PCI Express
- Gigabit Ethernet
- USB 2.0

Speed (Mbits/S) vs. Year

- 1986
- 1988
- 1990
- 1992
- 1994
- 1996
- 1998
- 2000
- 2002
- 2004
- 2006

40X increase in speed from USB 1.1 to USB 2.0
Hi-Speed Enables Multi-ADC Systems

DMM-Based Systems

- Relays
- ADC
- Data to PC at 1.8 MB/s (GPIB)

NI CompactDAQ

- ADC
- ADC
- ADC
- ADC
- Timing and Bus Controller (NI-STC2)
- Data to and from PC at 60 MB/s (USB 2.0)
Shared Bandwidth

60 MB/s total per root hub
USB Distance

• 5 m cables between up to 5 hubs (30 m total)
• Some companies make USB extenders
  – CAT 5
  – Fiber
  – Wireless
## USB Transfers

<table>
<thead>
<tr>
<th>Transfer Type</th>
<th>Format</th>
<th>Retry on Error</th>
<th>Available Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>USB-Defined</td>
<td>Yes</td>
<td>20% of Frame - HS 10% of Frame - FS</td>
</tr>
<tr>
<td>Isochronous</td>
<td>Raw</td>
<td>No</td>
<td>80% of Frame - HS 90% of Frame - FS</td>
</tr>
<tr>
<td>Interrupt</td>
<td>Raw</td>
<td>Yes</td>
<td>Uses All Available Bus Bandwidth</td>
</tr>
<tr>
<td>Bulk</td>
<td>Raw</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

No Lost Data
# USB DAQ Improvements

<table>
<thead>
<tr>
<th></th>
<th>OLD</th>
<th>NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simultaneous AI/AO streaming</td>
<td>Difficult due to device restrictions</td>
<td>Signal streaming technology for up to 4 data streams</td>
</tr>
<tr>
<td>Single-point performance</td>
<td>Less than 10 Hz for some AO</td>
<td>More than 2 kHz for some AO</td>
</tr>
<tr>
<td>A/D converters</td>
<td>Single A/D converter</td>
<td>Multiple A/D per system for up to 32 total</td>
</tr>
</tbody>
</table>
NI Signal Streaming Technology

- Simultaneous waveform I/O
- High-speed streaming
- NI CompactDAQ and USB M Series
A More Intelligent Device

- Device contains element of driver
NI Signal Streaming Technology

Controller

STC2
I/O DMA 1
I/O DMA 2
I/O DMA 3
I/O DMA 4

I/O PORT

USB EP1
USB EP2
USB EP3
USB EP4

To PC

To PC
Demo: Simultaneous Data Streaming
Isolation Technology

- Avoid ground loops
- System and user safety
- Measure small signals on a large potential
The NI USB Family

- Bus-Powered
- Modular I/O for Sensors
- 1.25 MS/s AI/AO
- Low-Cost
Visit the Consultation Zone

• Discuss products and configure your application
• Obtain estimated costs or a quote to take with you
• Request a free consultation – an NI engineer will come to your office to:
  – Discuss your application and specialized topics
  – Demonstrate customized applications, examples, and products
• Schedule an onsite seminar at your location
Robert Berger

• BS Electrical Engineering from Texas A&M
• Joined NI’s Engineering Leadership Program in 2001
• Supported and trained customers for ~4 years
• Migrated to Long Island in April 2007
• Covers Long Island and NYC
• Available for demos, onsite seminars, technical consultation, specification assistance, loaner equipment...