White Rabbit for High-Precision, Wide-Area Synchronization

Rodney Greenstreet
Timing and Synchronization Technical Lead
National Instruments
Our Mission for Success

We create innovative computer-based products that improve everyday life by improving technology.

We give our customers a better solution for measuring and automating the world around them.
30 Years of NI Timing and Synchronization Innovation

- **GPIB Group Execute Trigger (1978)**
- **Real-Time System Integration (RTSI) Bus**
- **System Timing Controller ASIC (STC)**
- **Timing I/O ASIC (TIO)**
- **IRIG-B**
- **PXI Slot 2 System Timing**
- **Synchronization and Memory Core (SMC)**
- **IEEE 1588v1**
- **IEEE 1588v2**
- **GPS**
- **PXI Express**
- **Compact RIO**
- **PXI Platform**
- **Desktop Computers**
- **LabVIEW FPGA Timekeeper**
- **White Rabbit**

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>Desktop Computers</td>
</tr>
<tr>
<td>1994</td>
<td>PXI Platform</td>
</tr>
<tr>
<td>1998</td>
<td>Compact RIO</td>
</tr>
<tr>
<td>2003</td>
<td>PXI Express</td>
</tr>
<tr>
<td>2006</td>
<td>White Rabbit</td>
</tr>
<tr>
<td>2011</td>
<td>LabVIEW FPGA Timekeeper</td>
</tr>
</tbody>
</table>
PXI Timing and Triggering

Star Trigger Bus

System Controller → System Timing Slot
Peripheral → Peripheral
Peripheral → Peripheral
Peripheral → Peripheral

10 MHz CLK

10 MHz point to point
<1 ns skew

PXI_Trig
8-line parallel trigger lines

PXI_CLK10
10 MHz point to point
<1 ns skew

PXI_STAR
Point to point
<1 ns skew
PXI Trigger Bus (8 TTL Triggers)

Star Trigger

100 MHz Differential CLK

SYNC100

10 MHz CLK

Differential Star Triggers

PXI Express System Controller

PXI Express System Timing Slot

PXI Express Hybrid Peripheral

PXI Express Hybrid Peripheral

PXI Express Hybrid Peripheral

PXI-1 Peripheral
Synchronizing Multiple Chassis (Channel Expansion)
Boeing: Minimizing Ground Noise
Synchronized Microphone Array
Flyover Test Installation

- 427 Channels
- 102.4 kS/s
- 100m
- 405 Low Cost Microphones
- 8x 200m Fiber

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Synchronization Technologies

Precision

- $10^{-12}$ sec
- $10^{-9}$ sec
- $10^{-6}$ sec
- $10^{-3}$ sec
- sec

Proximity

- $<10^{-4}$ m
- $10^{-2}$ m
- $10^0$ m
- $10^1$ m
- $10^2$ m
- $10^3$ m
- $10^4$ m
- $10^5$ m
- Global

Signal-based

- On-chip
- PXI
- PXI Multichassis

Time-based

- IRIG-B
- IEEE-1588
- NTP
- TCP/IP Messages
- GPS

Global

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Signal-Based

Share Physical Clocks / Triggers

Time-Based

Share Time
Ethernet (1588)
GPS
Etc.

Generate Signals

Generate Signals
TClk Reference Point

Time-Derived Clk10

Master
Slave

FTE @ 12:00 p.m. - 80ns

Modified TClk for Time-Based Systems
Next Gen Synchronization

GPS

1588 &

IRIG DC or AM

PPS

Precision TimeKeeper

Sync’d PXI_CLK10
Sync’d DDS clock
Timestamping
Clock Generation

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PXI Trigger Bus (8 TTL Triggers)
Questions?

Sub-ns White Rabbit