
NATIONAL
INSTRUMENTS™

Overcoming High Speed Measurement Challenges

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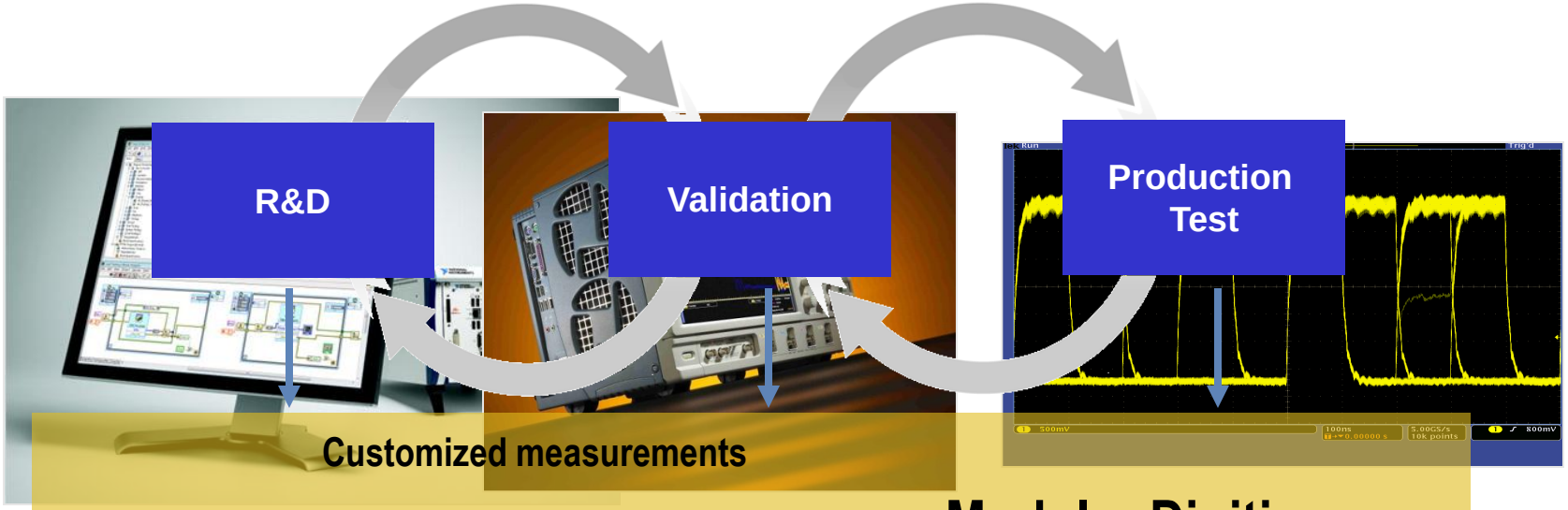
National Instruments

Overcoming High Speed Test Challenges

- Oscilloscope/Digitizer Performance Requirements
- Signal Integrity
- Optimizing Test throughout the Development Cycle
- ATE System Considerations

Test Throughout the Development Cycle



Oscilloscopes

A digitizer provides features optimized for automated test

- ► Quick Visualization
- ► Interactive Use
- ► High bandwidth

Hybrid Systems

Modular Digitizers

- ► High throughput
- ► Integration
- ► Compact size

The digitizing oscilloscope provides insight into the analog domain.

Very high bandwidth (multi-GHz)

Transitioning to GHz Signal Speeds

Faster data rates

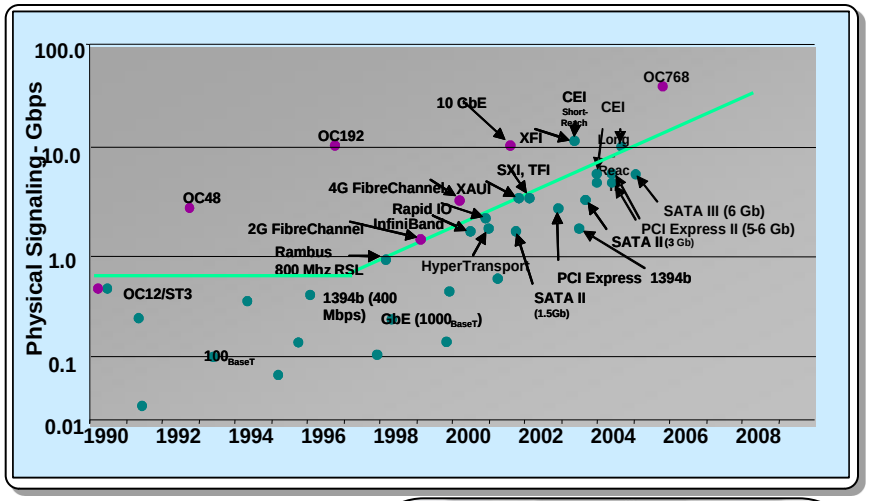
- 2.5Gbps, 3.125Gbps, 6.25Gbps…
- Multiple data lanes

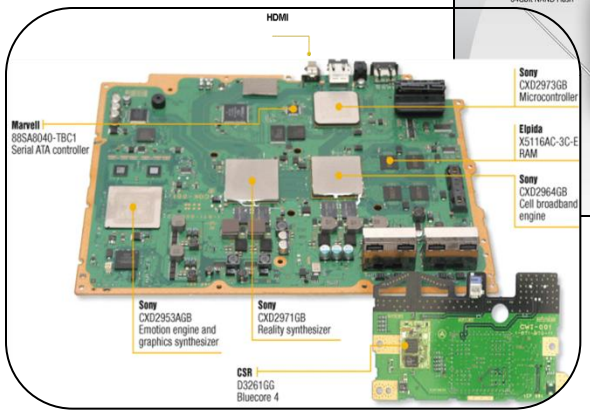
Greater design complexity

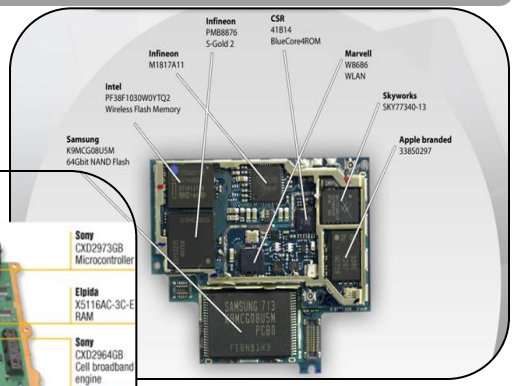
- Circuit performance
- Circuit density and power

Open Standards

- Interoperability key to success
- Compliance test requirements





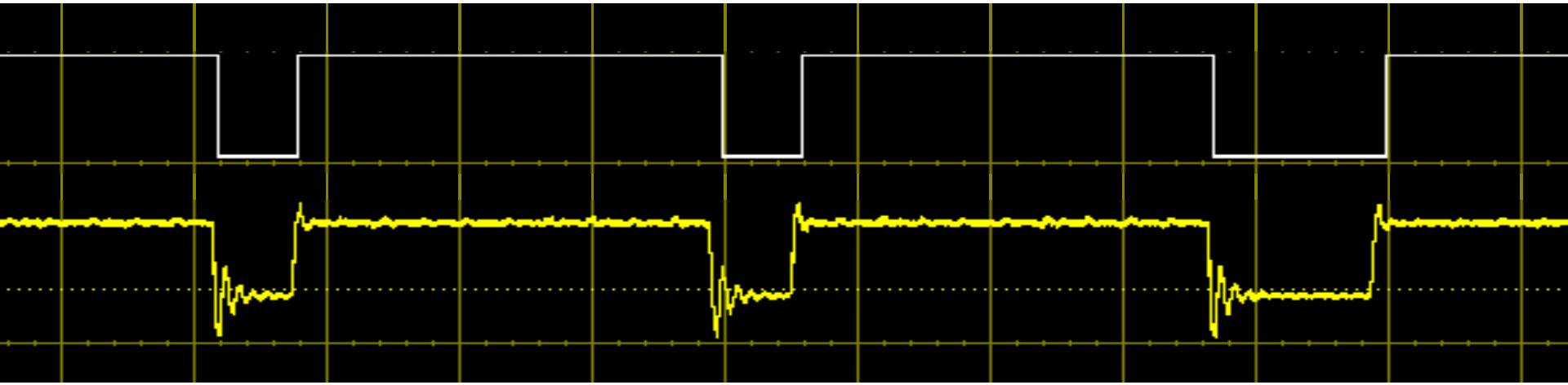


“There are two kinds of designers . . .

those that have signal integrity problems

. . . and those that will.”

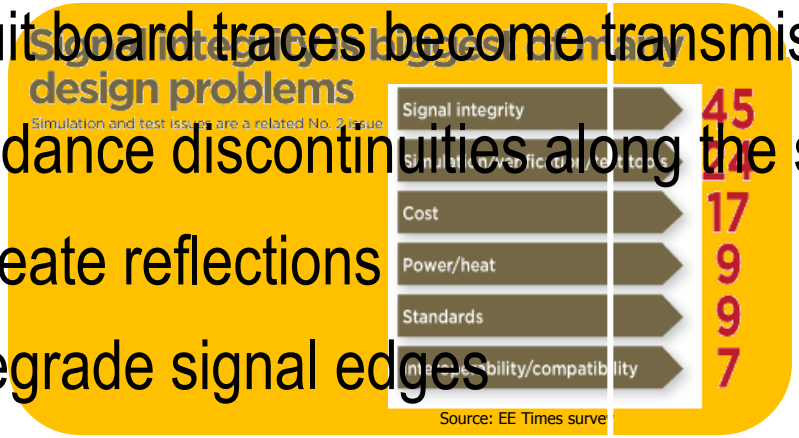
Sun Microsystems

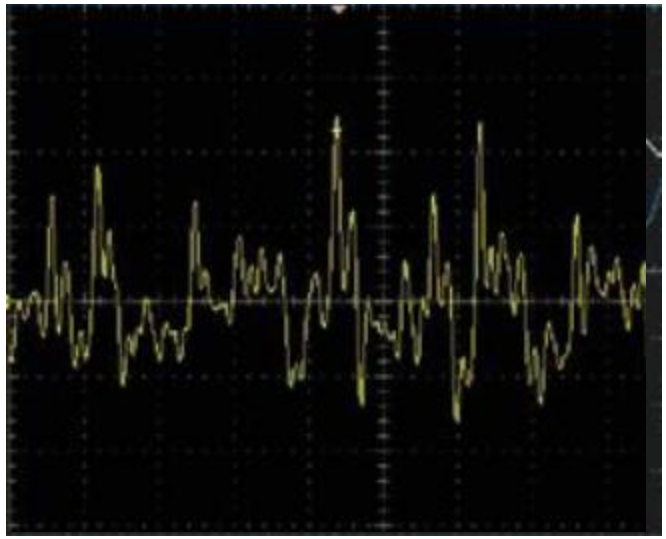


High Speed Test Challenges

Signal integrity is critical

- Circuit board traces become transmission lines
- Impedance discontinuities along the signal path:
  - Create reflections
  - Degrade signal edges
  - Increase crosstalk
- EMI goes up
- Ground bounce increases with higher current





What is Signal Integrity?

The term “integrity” means “complete and unimpaired.”

A digital signal with good integrity has:

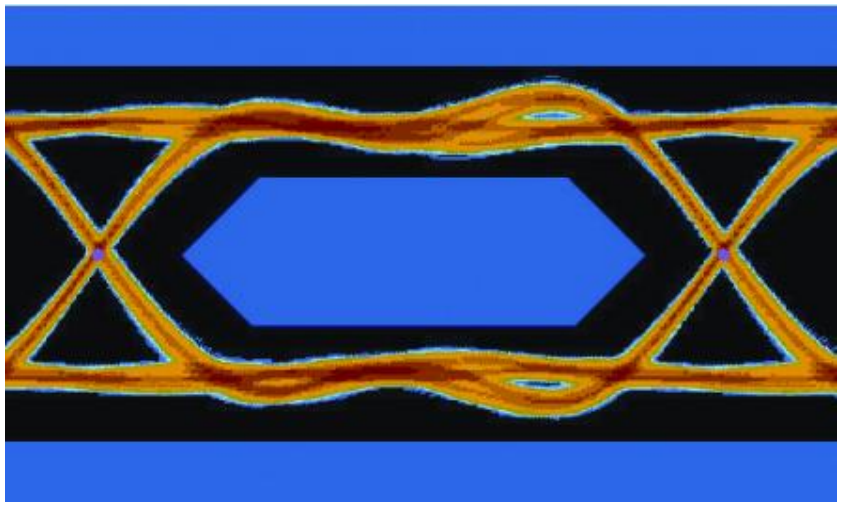
- Clean, fast transitions
- Stable, valid logic levels
- Accurate placement in time
- Free of transients

Testing in Design

How Do You Measure Signal Integrity?

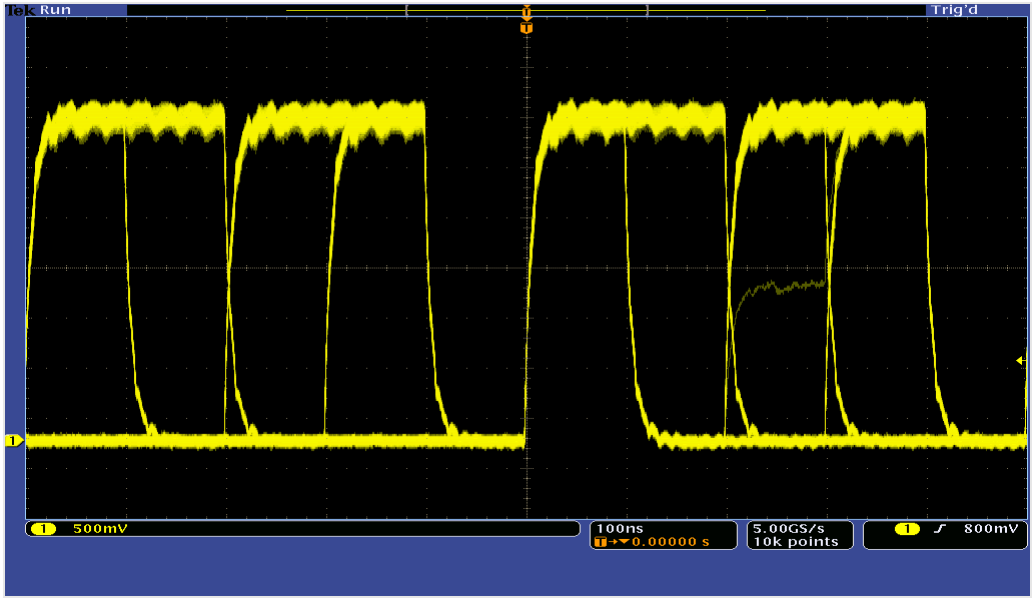
- Visual tool to observe signal integrity on a clocked bus
- Overlays waveform traces from many successive unit intervals
- Signal integrity factors cause “blur”:
  - Jitter (horizontal)
  - Noise (vertical)

Eye Diagram



Oscilloscopes Isolate Analog Deviations

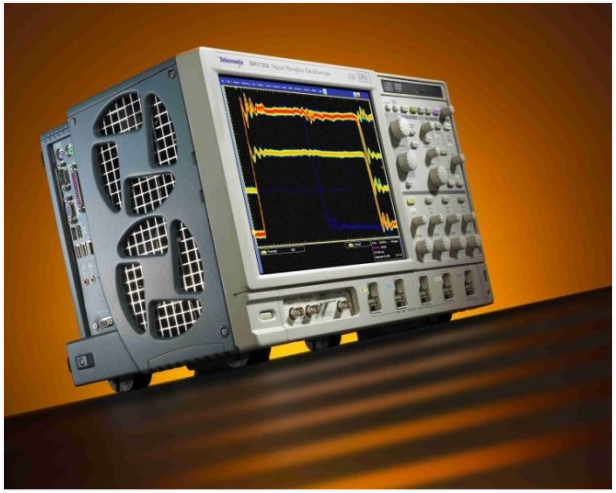
The digitizing oscilloscope provides insight into the analog domain.



- Displays waveform details, edges and noise
- Detects and displays transients
- Precisely measures timing relationships

Different Types of Oscilloscopes

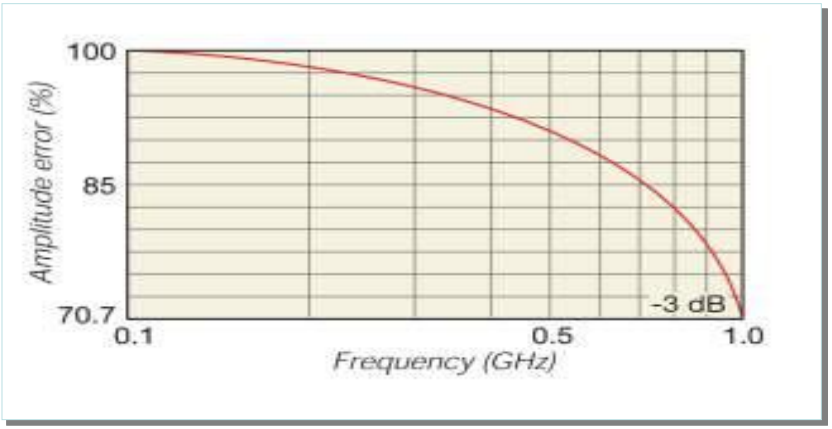
- **Digital storage oscilloscope (DSO)**
  - Low-repetition rate signals with fast edges or narrow pulses
  - Capture one-time events and transients
- **Digital phosphor oscilloscope (DPO)**
  - Digital troubleshooting
  - Find intermittent signals
  - Eye diagram and mask testing
- **Sampling oscilloscope**
  - Capture repetitive signals with high frequency components
  - Uses sequential equivalent-time sampling to achieve bandwidths up to 100 GHz



Tektronix DPO7000 Series

Measurement Bandwidth

- **Oscilloscope Bandwidth**
  - Must have sufficient bandwidth to capture high frequency components
  - Bandwidth specified at -3 dB point

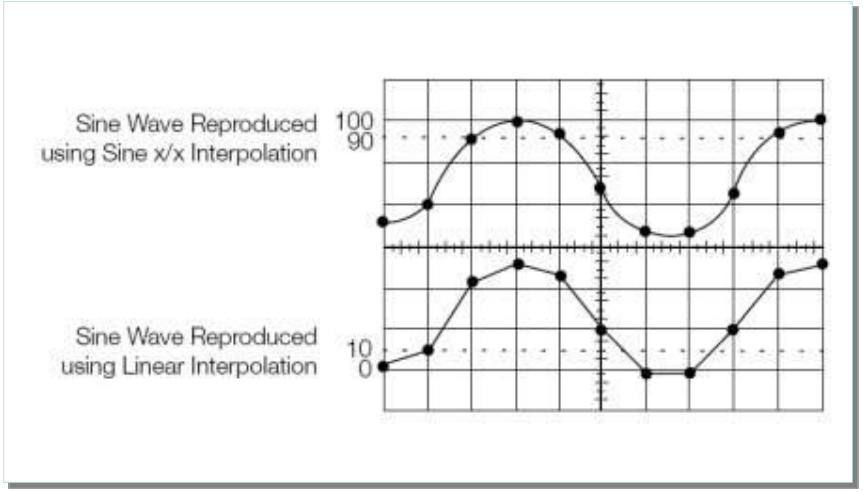


Bandwidth ≥ 5th Harmonic

- **The "5 Times" Rule**
  - For less than +/- 2% measurement error

Sample Rate

- **Sample Rate**
  - Determines how frequently an oscilloscope takes a sample
  - Faster sample rate, greater resolution and waveform detail
  - Wider margins in production test may demand less oversampling



- **Required Sample Rate**

$$\text{Sample Rate} > 2.5 \times f_{Highest}$$

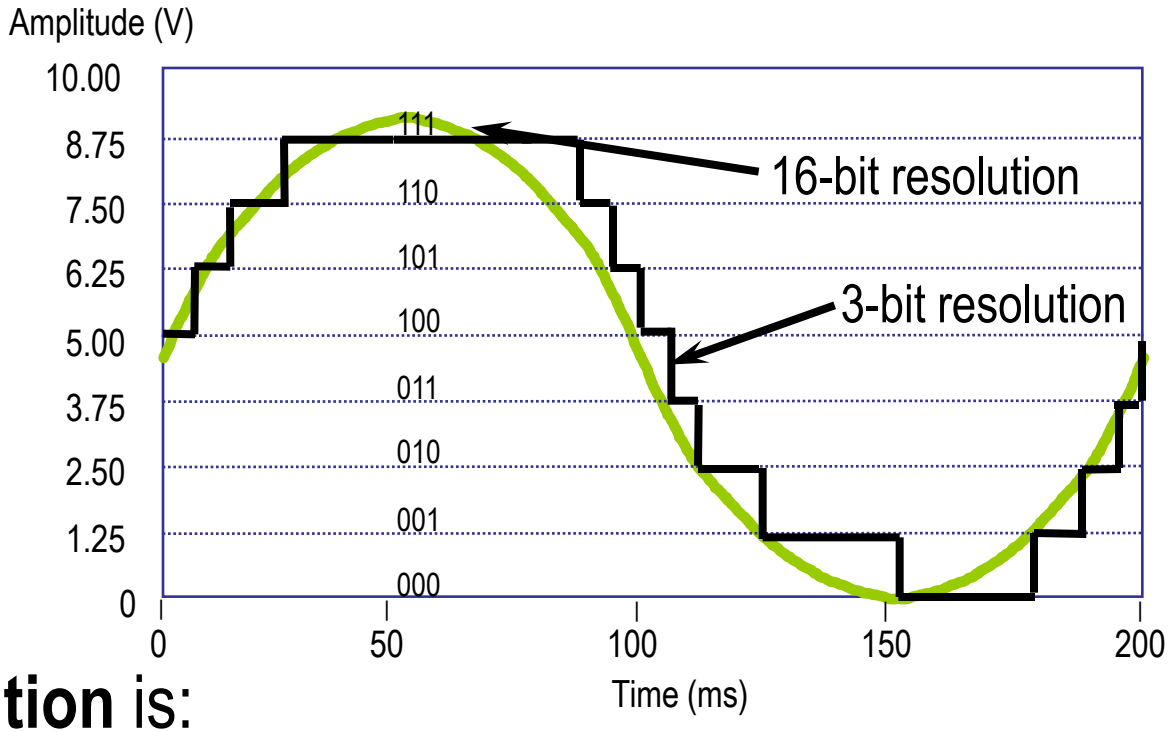
For sin(x)/x interpolation

$$\text{Sample Rate} > 10 \times f_{Highest}$$

For linear interpolation

Vertical Resolution

Vertical resolution refers to how many different voltage changes can be measured

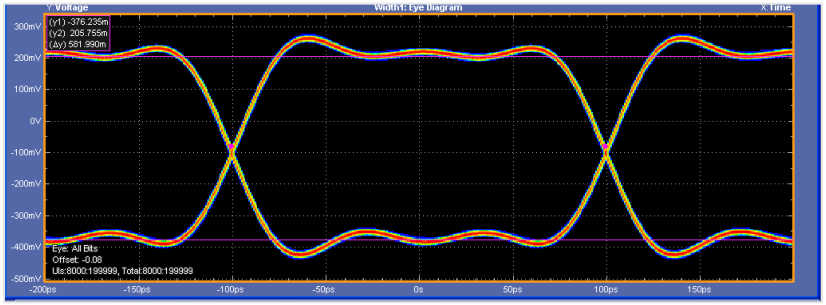


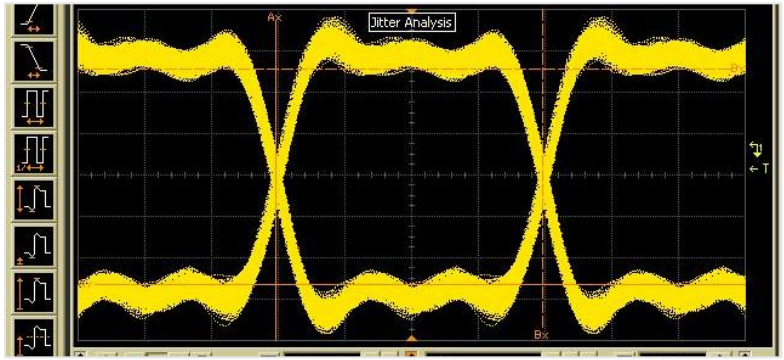
Effective bits of resolution is:

- A measure of how well an A/D system can digitize the shape of an ideal sine-wave input, *and*
- Commonly affects amplitude noise and jitter

ENOB for High Speed Measurements

- Input the same 5 Gb/s signal to both instruments
- **High ENOB** means more margin, better repeatability!



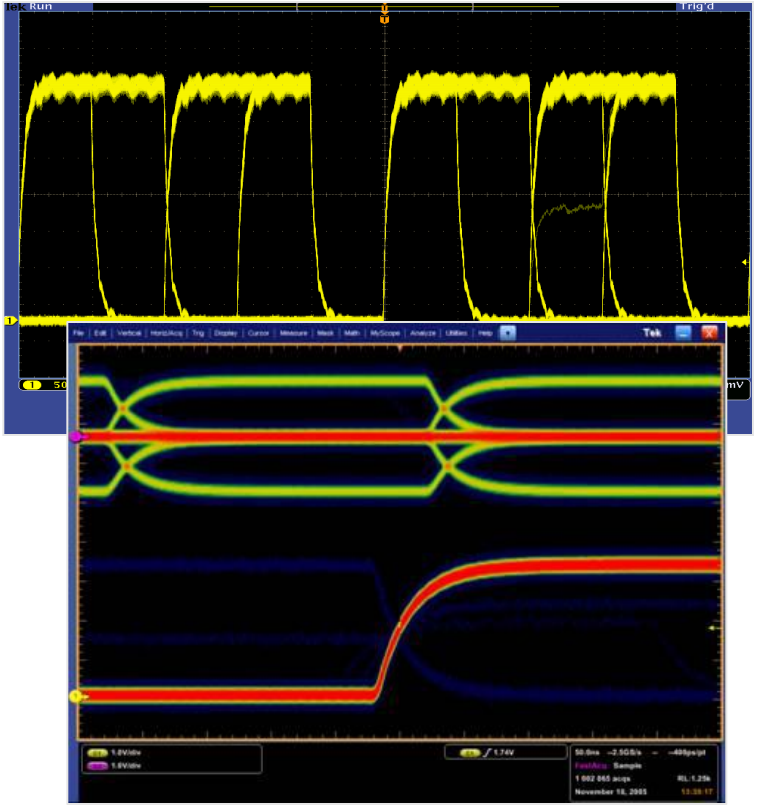


Measurement	Vendor T	Vendor A
TIE Jitter	3.08 ps	11.4 ps
Eye Height	582 mV	521 mV

Event Capture

- **Waveform Capture Rate**
  - Determines how frequently the oscilloscope captures a signal
  - Higher waveform capture rate, greater probability of quickly capturing transient anomalies

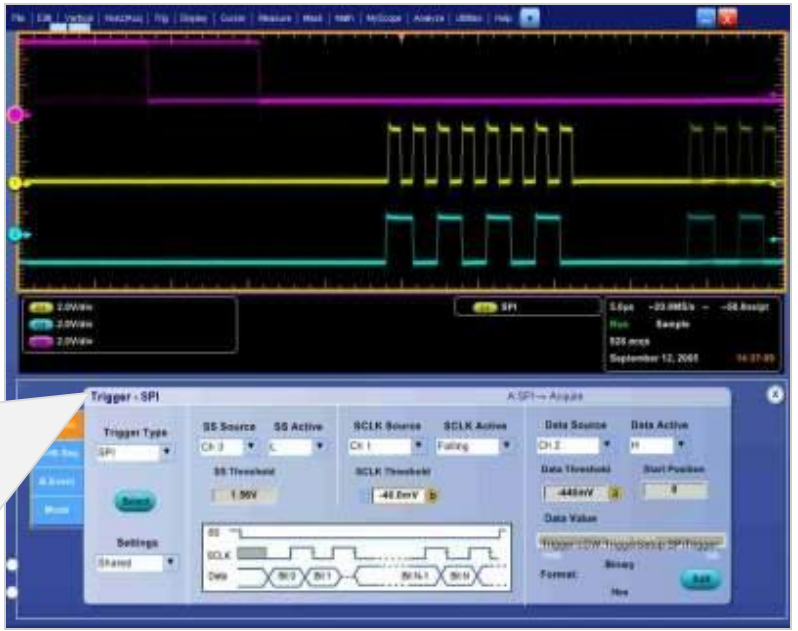
- **Digital Phosphor (DPO™) Provides**:
  - Captures thousands of acquisitions in seconds vs. minutes or hours
  - Identifies rare anomalies or glitches
  - Color coded frequency of occurrence



>250k waveform/s capture rate on all channels simultaneously

Triggering

- Trigger sets condition at which oscilloscope acquires data
  - Verification that an “event” actually occurred
  - Complexity rises on fast communications system designs



Important Trigger Types:
- Edge level
- Slew rate
- Pulse characteristics
- Glitch
- Runt
- Setup and hold violation
- Serial digital patterns

Testing in Production

ATE System Design

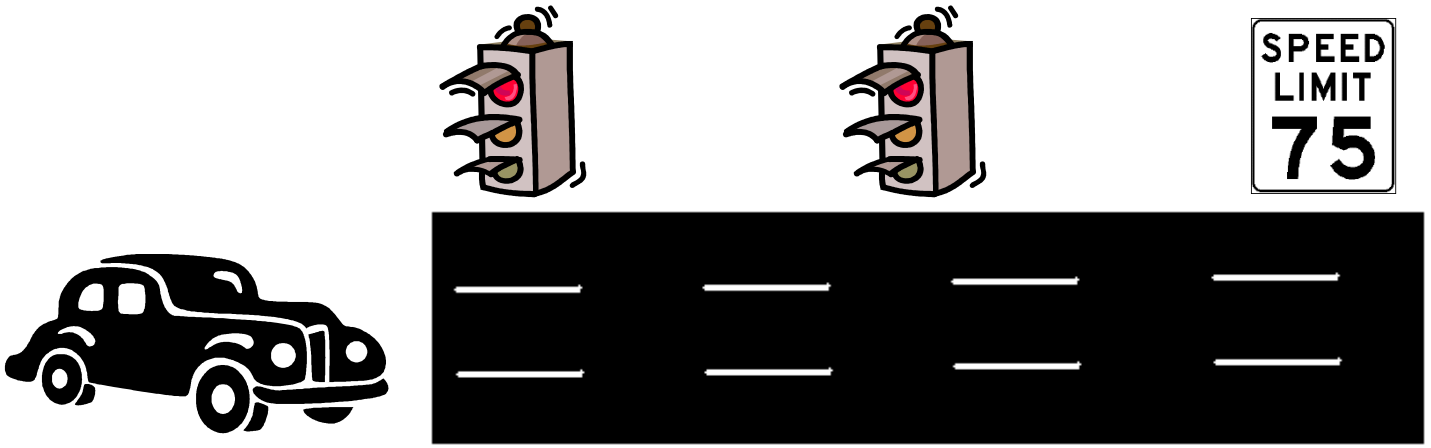
- **Common instrument considerations**
  - Measurement functionality
  - Instrument performance
- **Evaluate bus technologies of the instruments available**
  - Meets performance needs
  - Suitable for application
- **Various bus technologies are available**
  - GPIB
  - LAN
  - USB
  - PCI
  - PXI
  - Etc.

Bus Technology Considerations

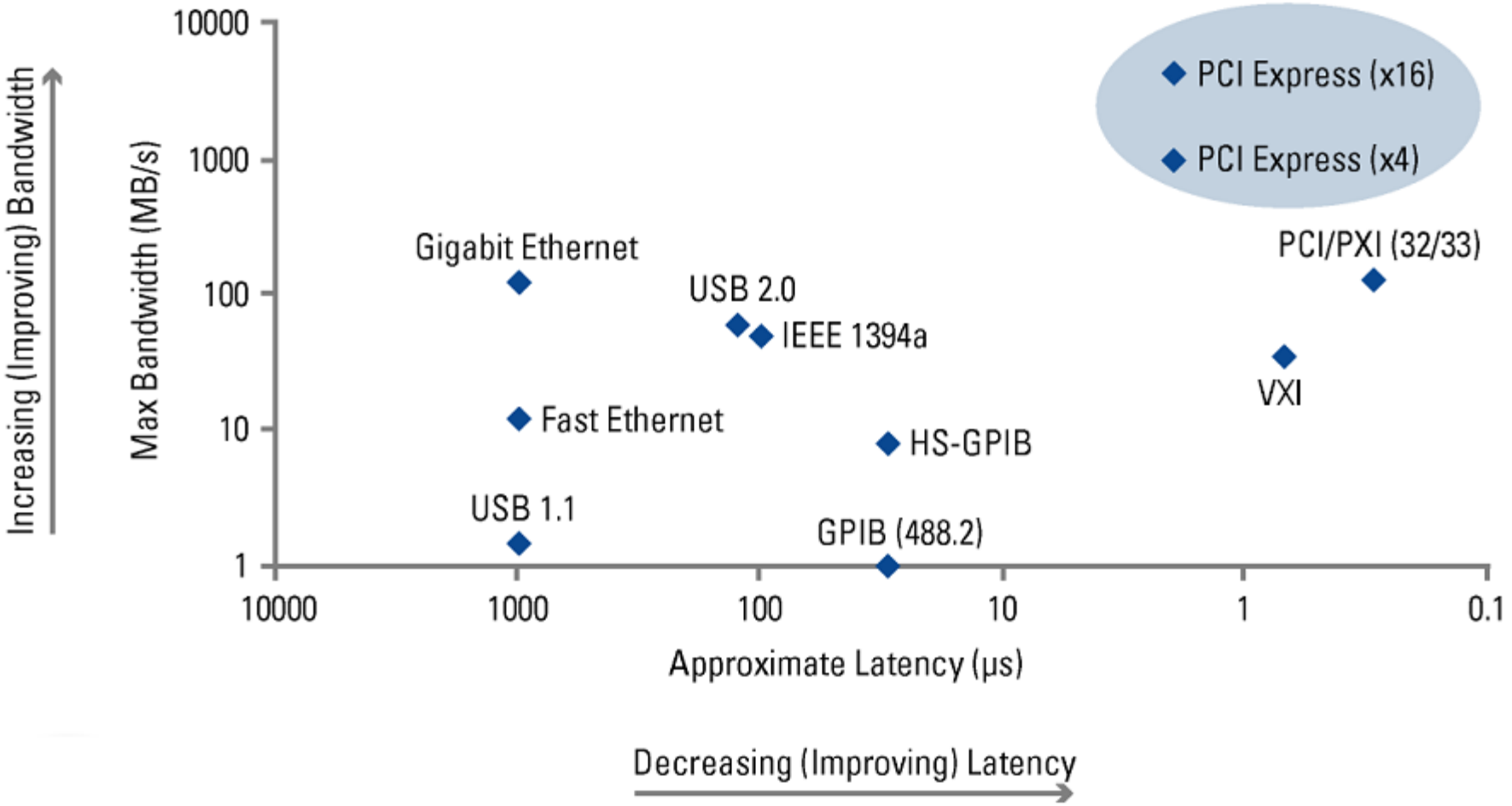
- **Bus factors that affect instrument performance**
  - Latency
  - Bandwidth
- **Other considerations**
  - Timing and synchronization
  - Distributed networks and remote monitoring
  - Standard software frameworks

Latency and Bandwidth

- **Latency** measures the delay of transmission of data across a bus
- **Bandwidth** measures the rate at which data is sent across the bus (typically MBytes/s)



Industry Bus Performance



PXI Combines Standard Technologies

Controller
• Embedded PC or remote PC / laptop interface
• Runs all standard software

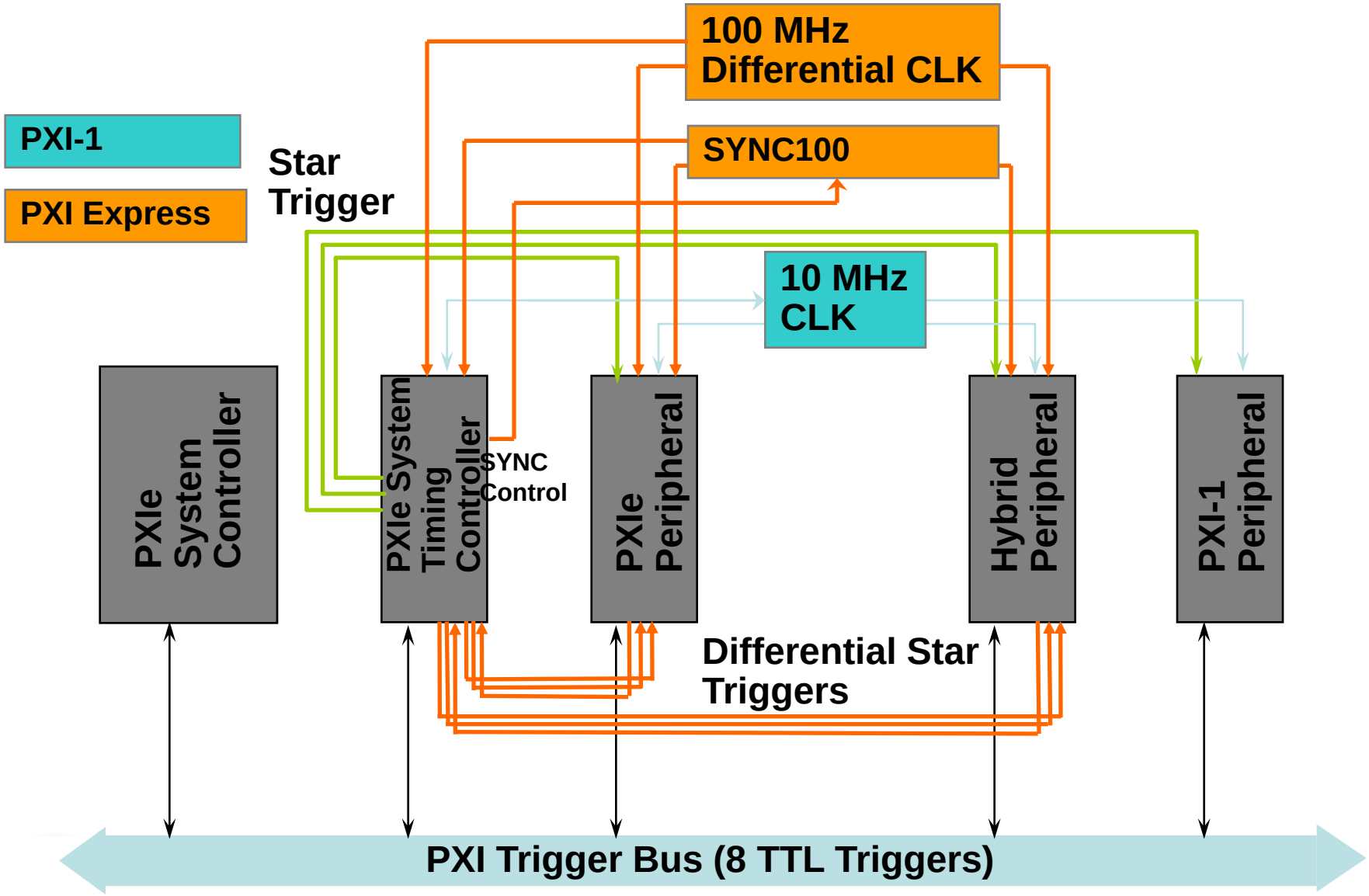
Chassis

PXI Backplane
•PCI bus
•Timing and Synchronization

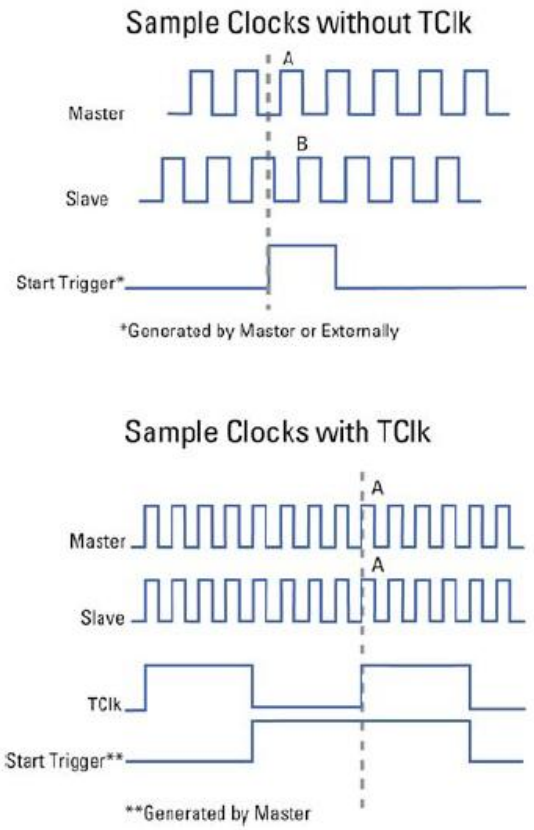
Peripheral Modules

Timing and Synchronization

- Used for handling synchronous events
  - For example, starting signal generator and digitizer at same time
- Used for performing asynchronous events
  - For example, handshaking with switch and DMM, Arb, and so on
- Backplane buses provide most direct and accurate method of synchronization (PXI and VXI)
- IEEE 1588 protocol provides external synchronization (LAN)
- Input and output triggers available for GPIB, USB, and 1394


100 MHz
Differential CLK
SYNC100
PXI-1
PXI Express
Star
Trigger
10 MHz
CLK
PXIe
System
Controller
PXIe System
Timing
Controller
SYNC
Control
PXIe
Peripheral
Hybrid
Peripheral
PXI-1
Peripheral
Differential Star
Triggers
PXI Trigger Bus (8 TTL Triggers)

NI Trigger Clock Provides Picosecond Level Synchronization

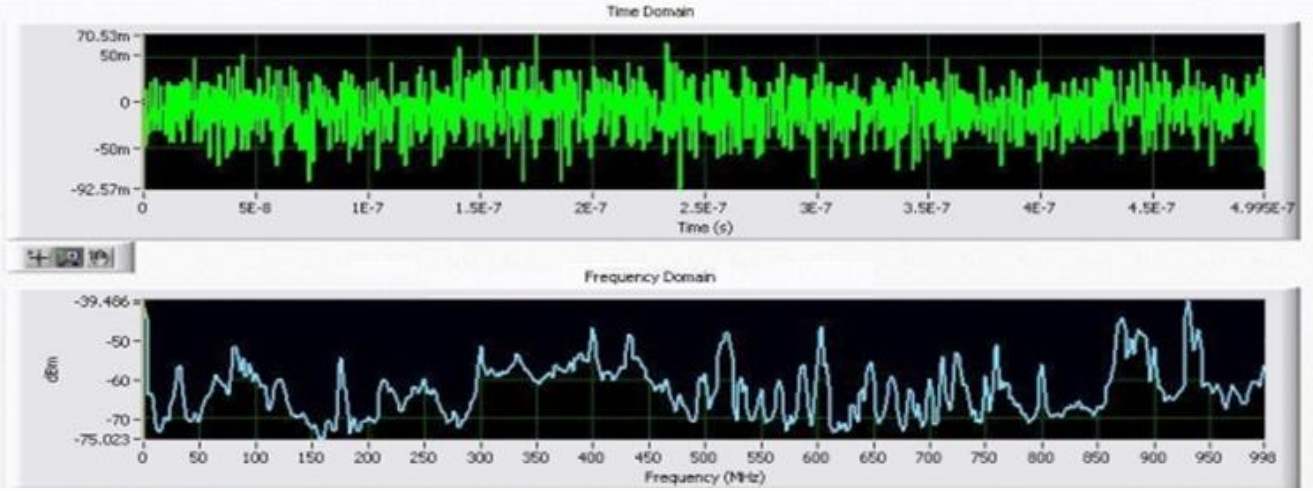


Trigger Clock (TClk)

- NI Modular Instruments
- < 200 ps skew w/ no calibration
- <20 ps skew w/ calibration
- Aligns sample clocks that are not aligned even if the are phase locked
- Enables accurate, stable triggering using “slow” TClk signals
- Uses the PXI timing and synch. bus

Modular Hardware, Flexible Software

- Instrument acquires/generates data
- Software determines how data is created/viewed
- Digitizer – oscilloscope, spectrum analyzer, transient analyzer, and frequency counter



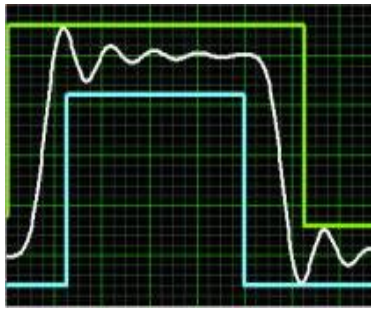
Additional Software-Defined Analysis

Standard

- Rise time
- Fall time
- Frequency
- Period
- Vpp
- Min
- Max
- Cycle RMS
- Duty cycle
- FFT
- + pulse width
- - pulse width
- Amplitude
- High
- Low
- RMS
- Area
- Cycle mean
- Overshoot

Signal Processing

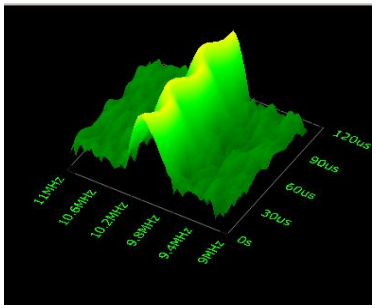
- Windowing
- Averaging modes
- Digital IIR Filters
- Digital FIR Filters
- Interpolation modes
- Limit mask
- Derivative
- Multiple/divide channels
- Add/subtract channels
- Waveform average
- Channel-to-channel delay



Limit Mask

Spectral Measurements

- THD, SINAD, SNR, SFDR
- Specific harmonic level
- Power in band
- Adjacent channel power
- Occupied bandwidth
- Peak detection
- Zoom FFT
- Frequency response
- Joint-time frequency analysis
- Super resolution spectral analysis



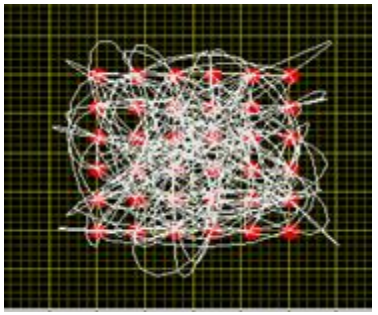
Time/Frequency Plot

Modulation

- AM, PM, FM demodulation
- Digital demodulation
- Frequency drift
- Error vector magnitude
- Phase error
- Magnitude error
- Scatter/constellation plots

Statistical Analysis

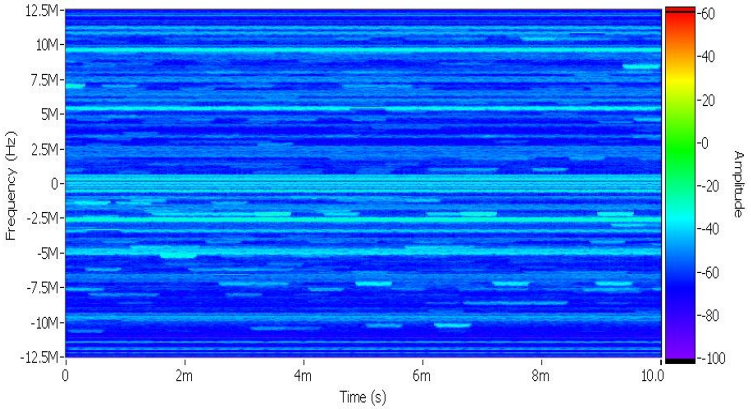
- Histograms
- Standard deviation
- Variance

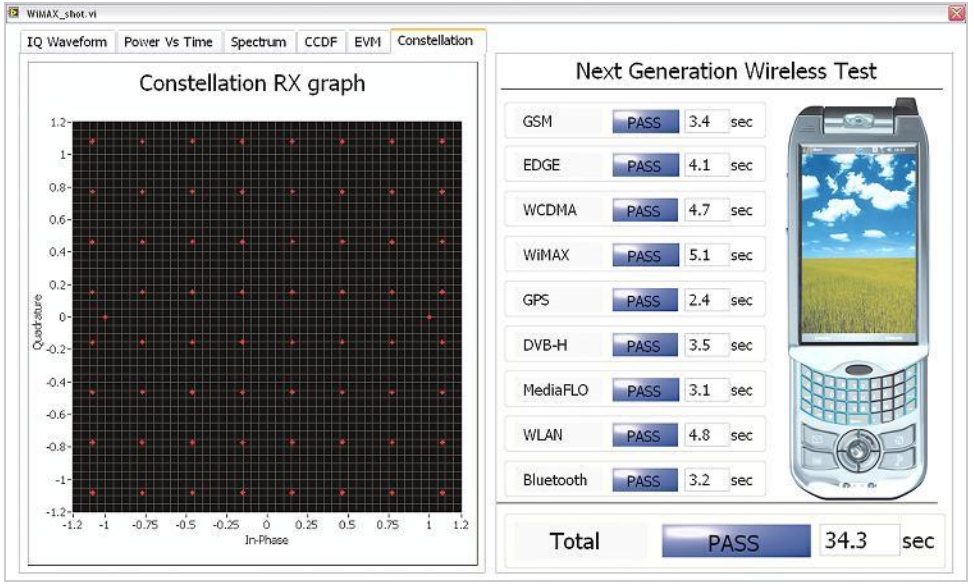


Constellation Plot

Custom Analysis

- View data in a format tailored to your application





Considerations for Automated Test Systems

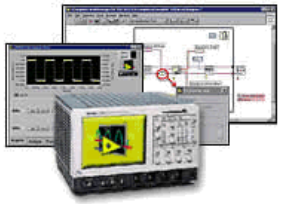
- Measurement speed and **data throughput**
- Multi-channel **synchronization**
- **Integration** with other instruments in a test system

The Future of Test

Tektronix and National Instruments Relationship

2000 | 2006 | 2007 | 2008 | 2009

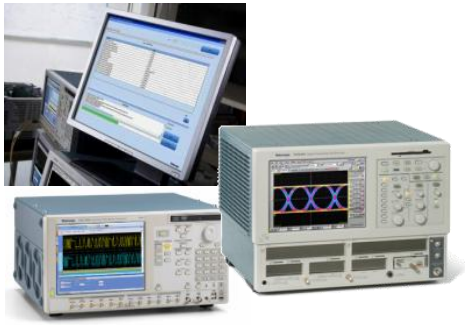
TDS7000 and LabVIEW



Design

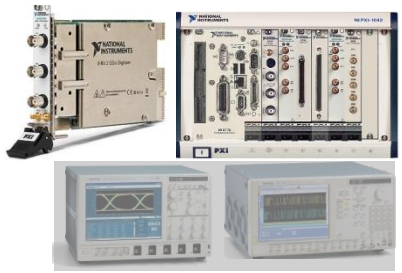
DPO4000 and SignalExpress

Design



Serial data analysis and TestStand

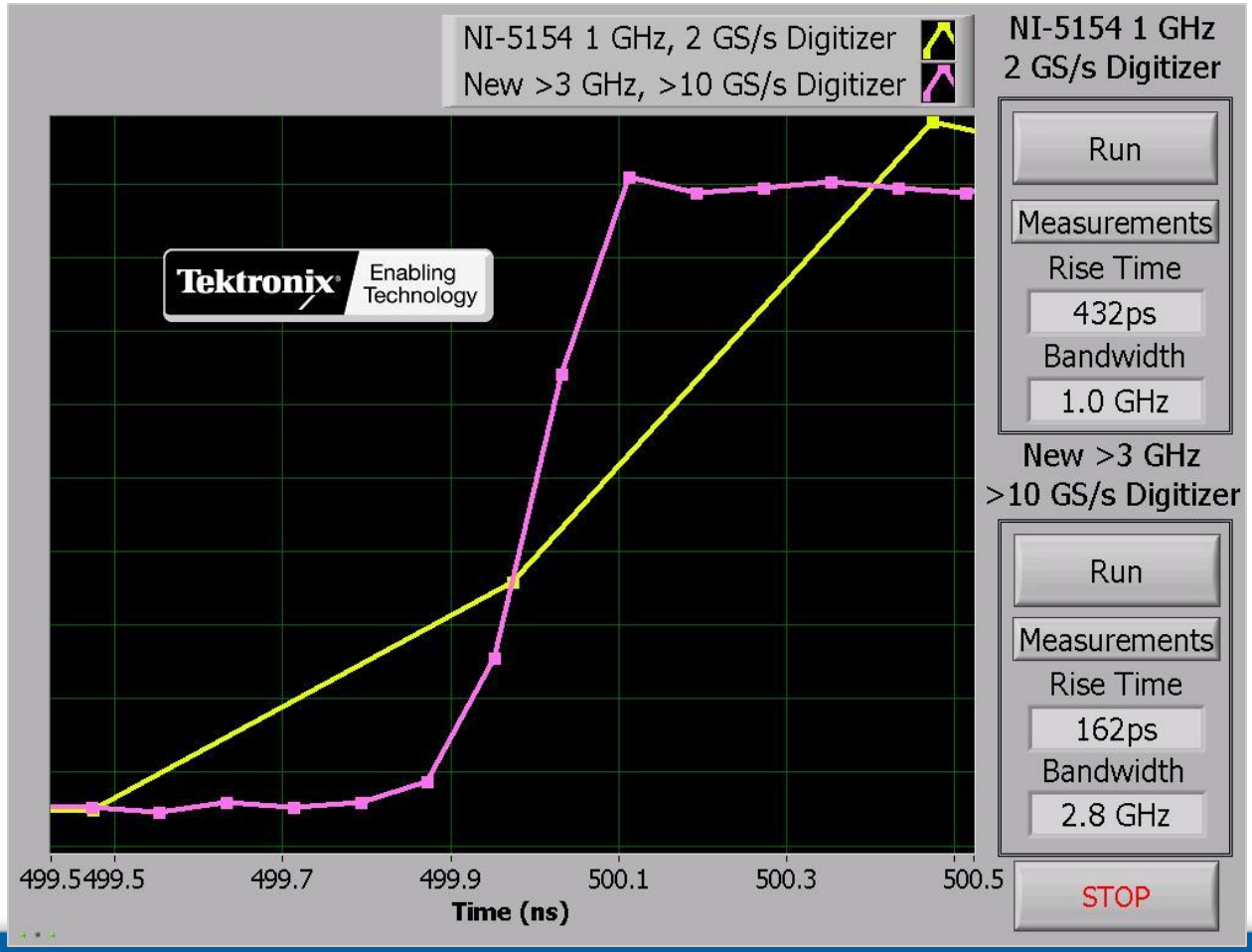
Design/Compliance Test



Industry's fastest PXI digitizer and hybrid test systems

Manufacturing Test Data Acquisition

NI and Tektronix Co-Develop Industry's Fastest PXI Digitizer



Q & A