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Join us at NIDays Europe 2019, the industry leading conference for automated test and automated measurement professionals. Take advantage of learning from industry trailblazers, network with like-minded peers, and increase your proficiency to develop cutting-edge applications.

NIDays Europe offers

- 100+ technical sessions over two days
- 100+ demos from 50+ exhibitors on the exposition floor
- Networking with industry peers
- Access to NI leadership, sales, and R&D
- Inspiring keynote speakers

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Who are we?

Who are you?

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Agenda

Time	Topic	Presenter	Demo
9:00	**Welcome and Introductions**		
9:15	**Lower the Cost of Test While Improving Time to Market with Better Cross-Functional Workflows**	Joshua Young	No
10:00	**Introduction to the PXI Platform**	Tarek Safwan	No
10:30	**Using a Modular Platform for Mixed-Signal Semiconductor Characterization** • Use InstrumentStudio™ to save project configurations, export measurement results, monitor instruments and perform interactive debugging • See how the digital capability of semiconductor ATE systems can be replicated with a lab-friendly footprint • Live demonstration of DUT characterization using modular instruments	Tarek Safwan	Yes
12:00	**Lunch/Networking**		
13:00	**Using a Modular Platform for RFIC Semiconductor Characterization**	Mher Minasyan	Yes
13:30	**RF Measurement Optimization with RFmx**	Mher Minasyan	Yes
14:15	**Beyond Bluetooth 5**	Mher Minasyan	Yes
14:45	Wrap-up and summary	All	

Purpose of this session

- Introduce NI’s core competencies and strategy in Semiconductor Test
- Create a better understanding of NI’s platforms used for Semiconductor Test
- Introduce our PXI Platform which is the core of all our solutions
- Introduce how our tools fit within your typical workflow and how you can leverage them
- Help you gain ideas on how to tackle the challenges you might face
- Align and identify future engagement opportunities
- Align and identify future event topics

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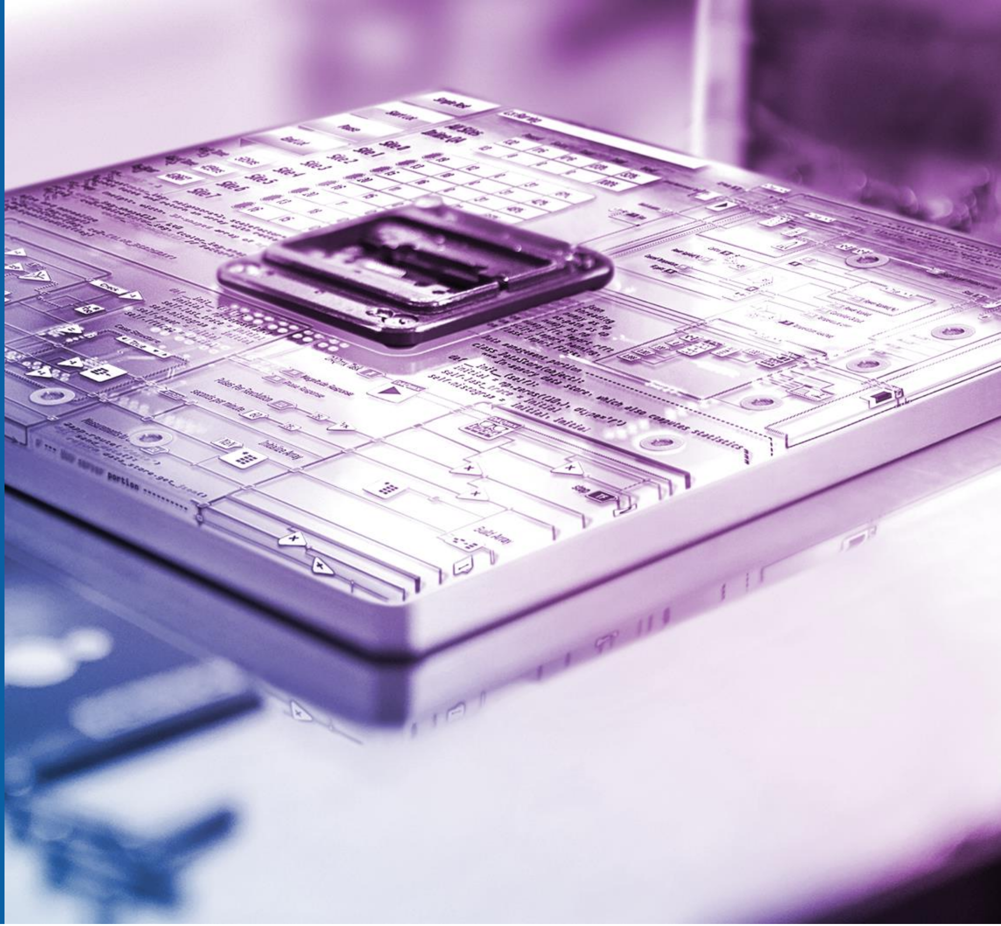
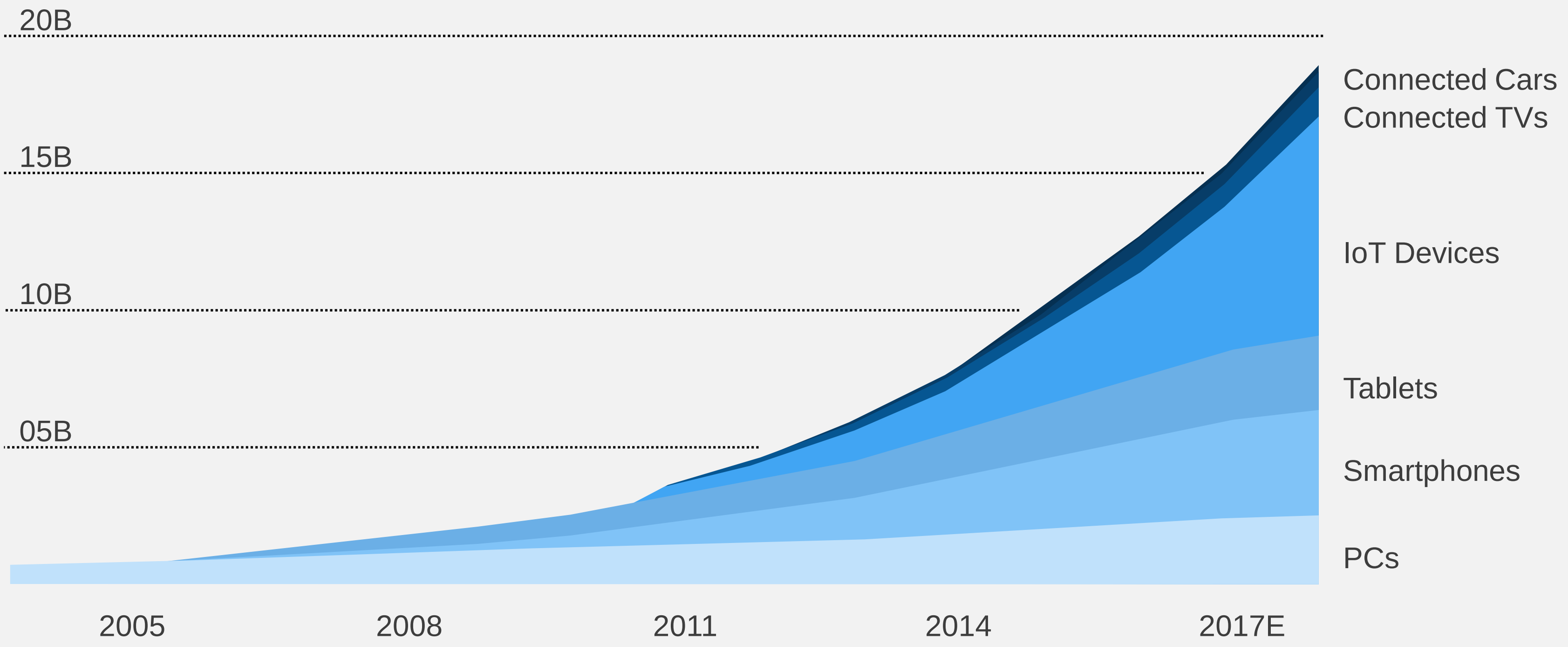
Lowering the Cost of Test While Improving Time to Market With Better Cross-Functional Workflows

Smarter Test From
Characterization to Production

Joshua Young
Semiconductor Account Manager
National Instruments



The Big Bang of Smart Devices



Source: BI Intelligence Estimates

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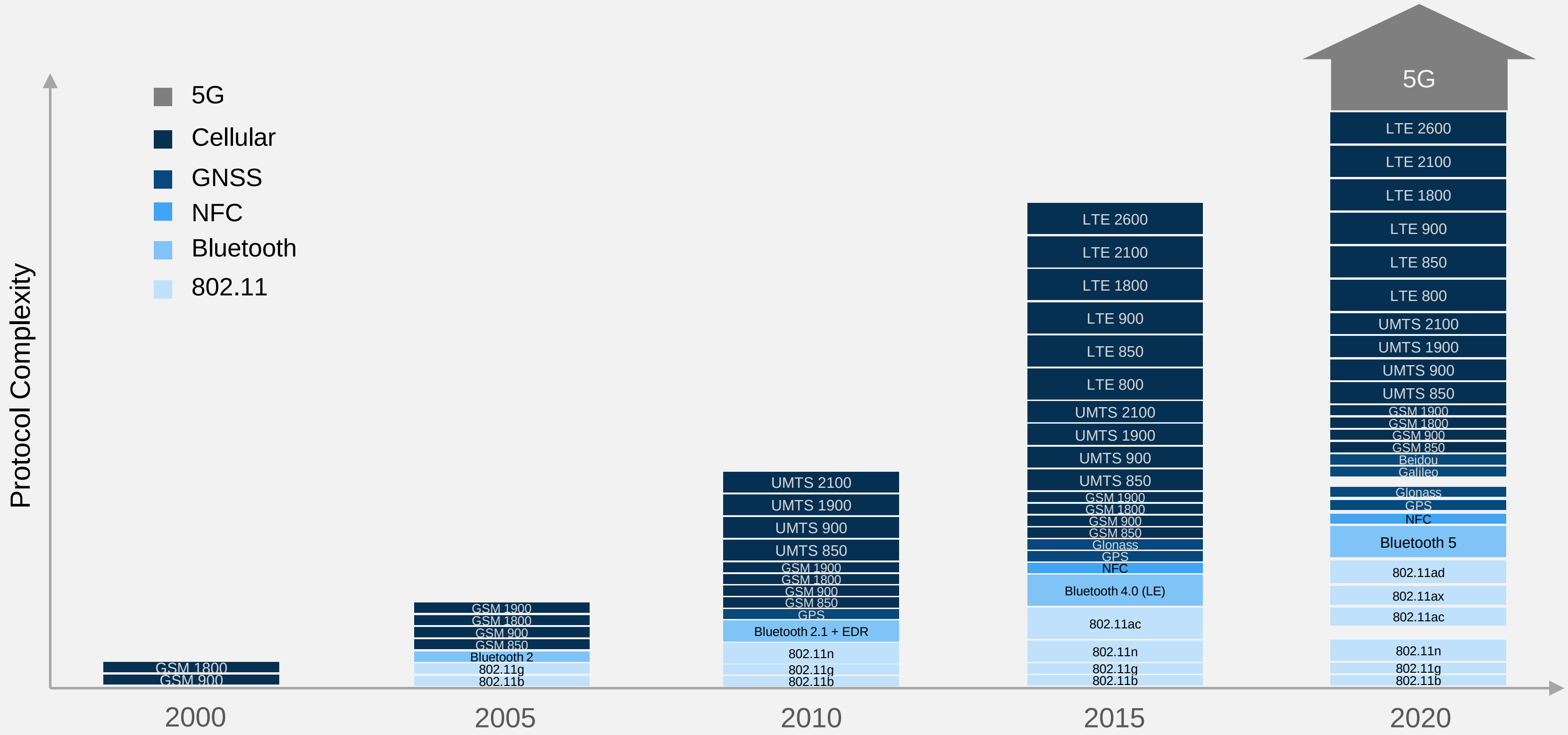
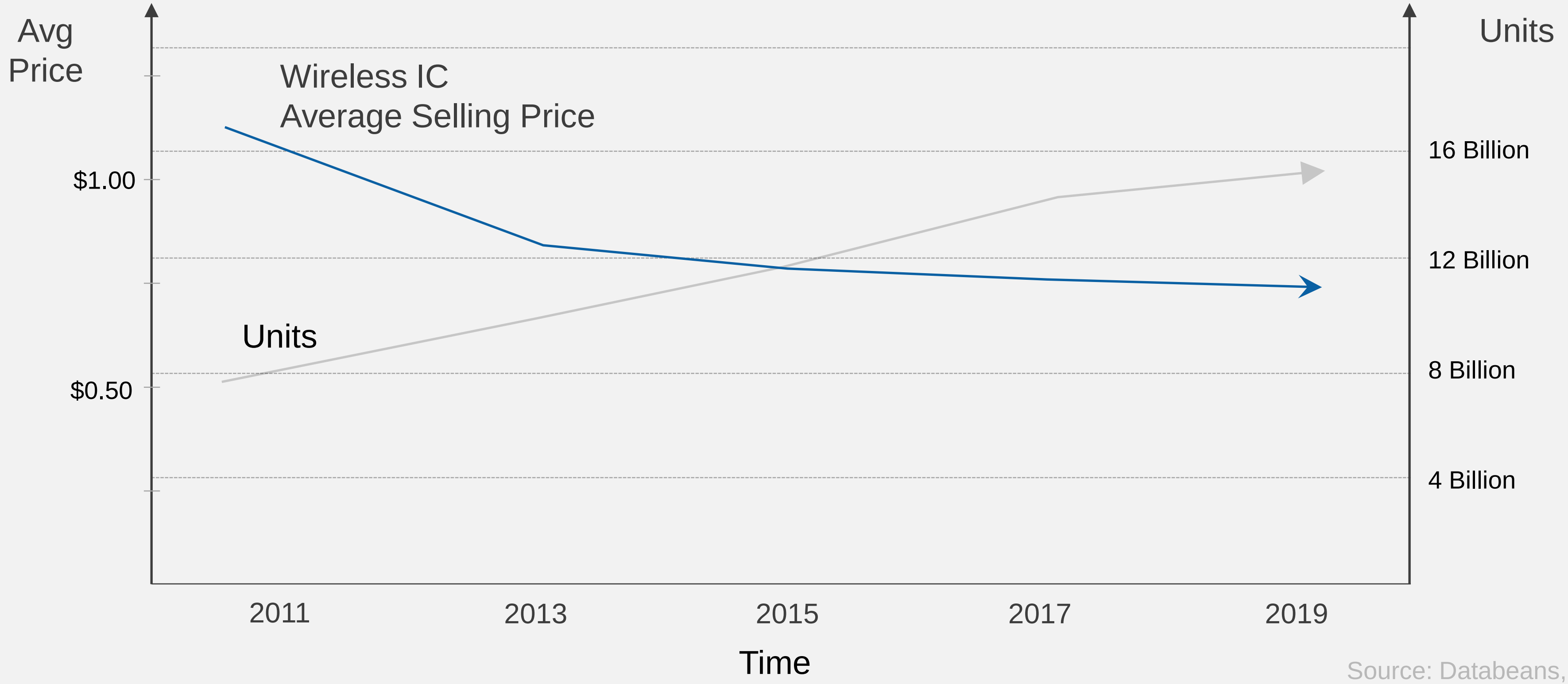
Increasing Complexity of Wireless Standards



Higher Integration with Cost Reduction



Source: Databeans, Inc.

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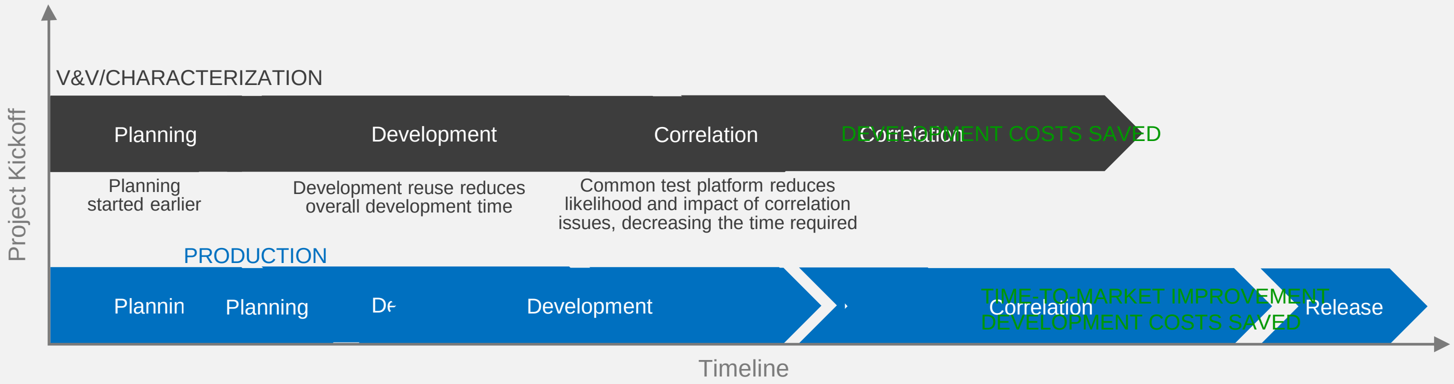
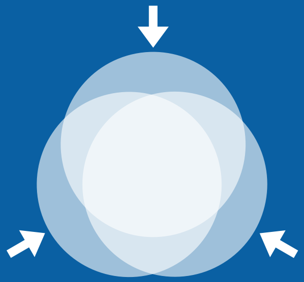
Optimized NPI Timeline

Traditional



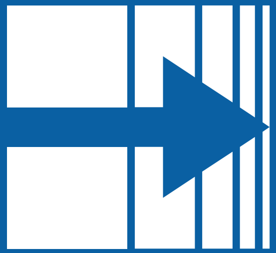
Unique Attributes of Smart Devices - Common Test Needs

CONVERGENCE



LOWER PRICE

RAPID CHANGE



- More functionality
- Ensure high reliability
- Lowest cost
- Fast time to market

Differences in the Philosophy and Infrastructure

Post-Silicon Characterization in Labs

- DUT design validation and performance characterization across a large spectrum of (data sheet) parameters and test conditions
- Interactivity with the DUT is a must
- Code performance and test time are a lower priority
- Single-site testing (in most cases)
- Analysis of results to provide feedback to design

Production Test in Manufacturing

- Parametric tests to validate functionality in wafer/package form
- Interactivity with DUT not required—go/no-go test
- Throughput is the highest priority
- Multisite test and optimized test times
- Post-analysis of results aimed at controlling process variation

INSTRUMENTATION

TOOLS AND SOFTWARE

Vendor Strategies for Test and Measurement

CLOSED

- “Vendor knows best”
- Fixed-functionality
- Closed ecosystem
- Customer pays

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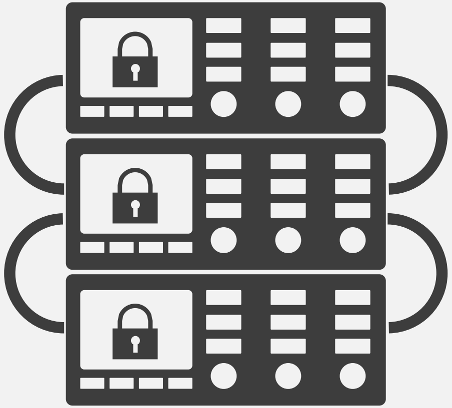
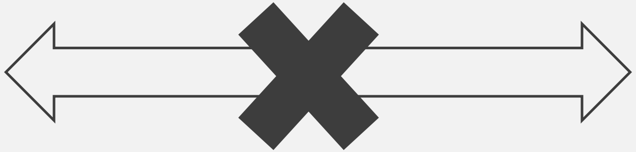
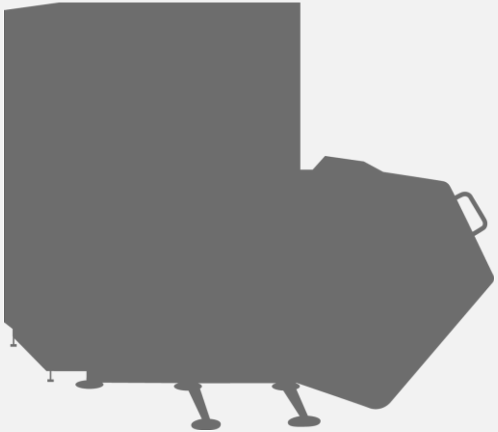


Box Instrumentation

Becoming a Business Risk



- Disconnect
- Long test cycles
- Increasing cost



ATE

Vendor Strategies for Test and Measurement

CLOSED

- “Vendor knows best”
- Fixed-functionality
- Closed ecosystem
- Customer pays

PLATFORM

- “Customer knows best”
- Customizable solution
- Open, vibrant ecosystem
- Customer designs

V&V Labs

- Designed for automation
- Optimized for test coverage
- Short test cycles

A Smarter Approach

Same Platform

Reduce time to market and operational costs through

- Easier correlation
- Test IP reuse
- Proficiency on shared tools
- Common development and debug environments

Production Floor

- Designed for test cell
- Optimized for throughput
- Cost-effective

National Instruments is **uniquely positioned in the market** to serve the needs of semiconductor customers across lab and production environments with a common software and hardware platform.

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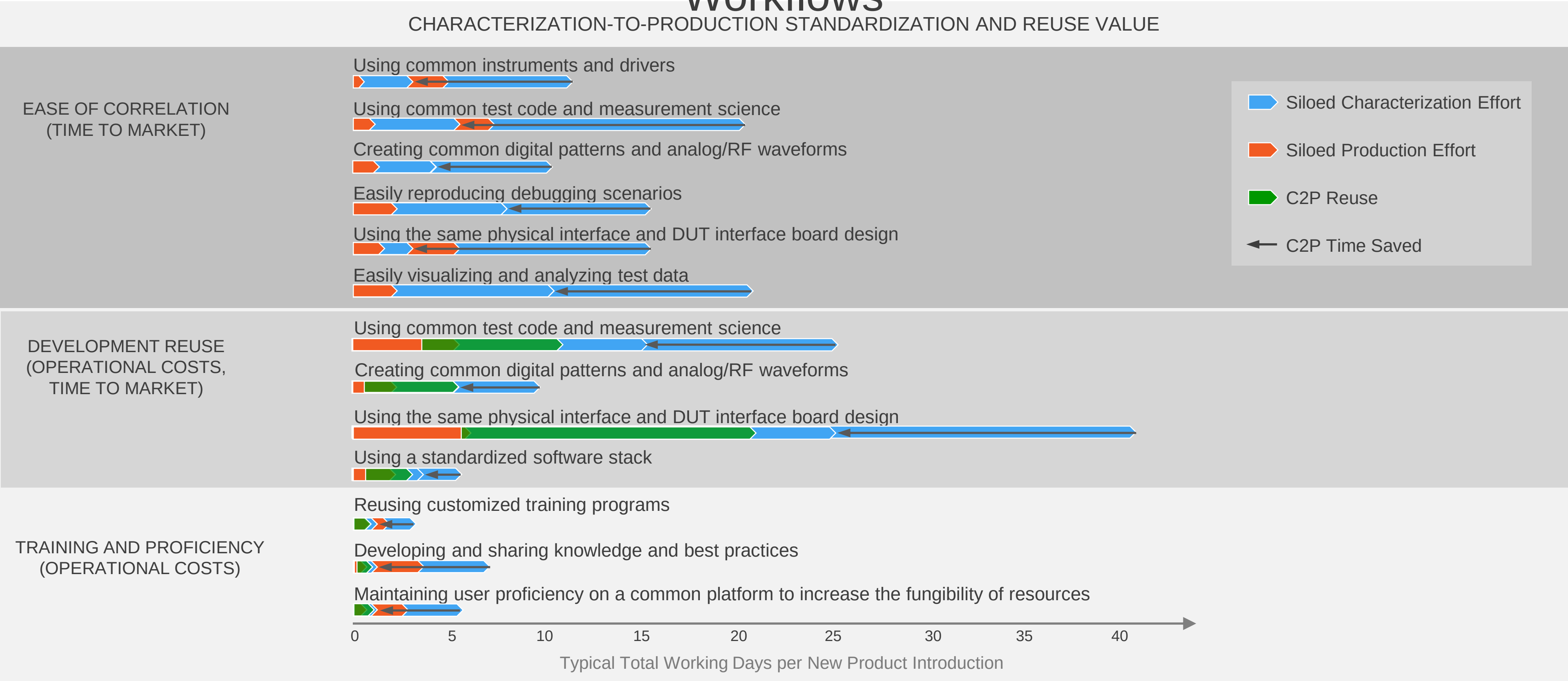
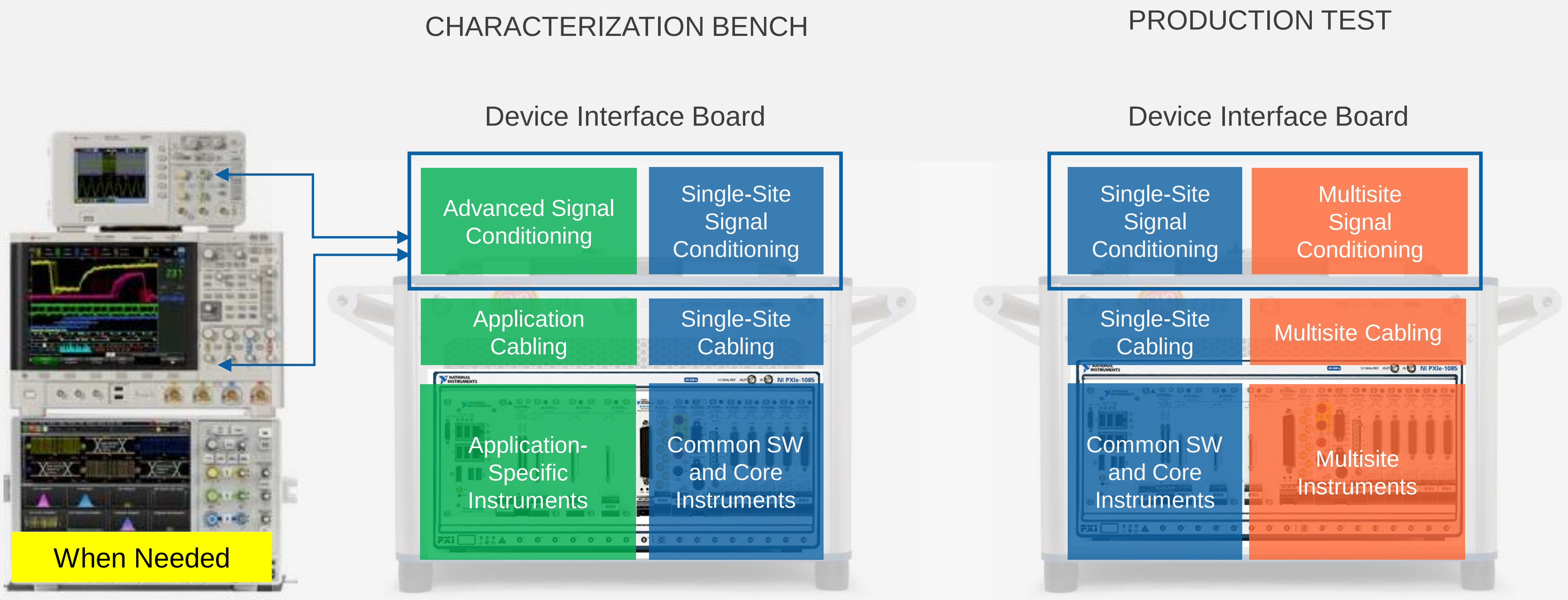
Increase Productivity With Platform Standardization and Better Workflows



Standardizing Instrumentation and Interfaces



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Test Code Reuse Analysis

CHARACTERIZATION TEST PLAN	PRODUCTION TEST PLAN	
Test 1 … Test 15	Test 1 … Test 15	▪ **High reuse potential** ▪ Low-risk measurements (leakage, continuity, standards-based tests, etc..)
Test 16 … Test 20		▪ **Limited Reuse Potential** ▪ Complex/expensive measurements ▪ Greater coverage in characterization
Test 25 … Test 30	Test 25 … Test 30	▪ **Reuse within characterization** ▪ High-end measurement and/or parameter sweeping ▪ **Reuse within production** ▪ Requires optimization for throughput

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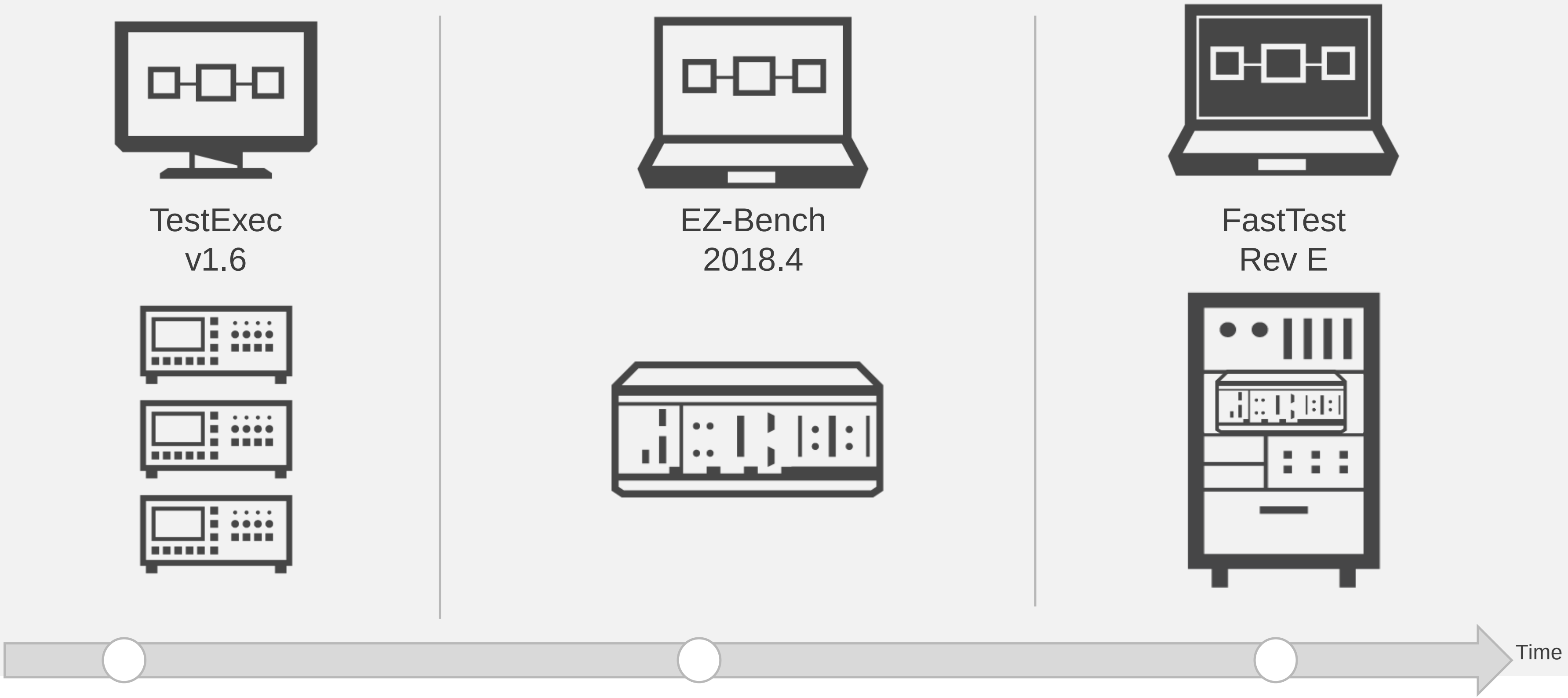
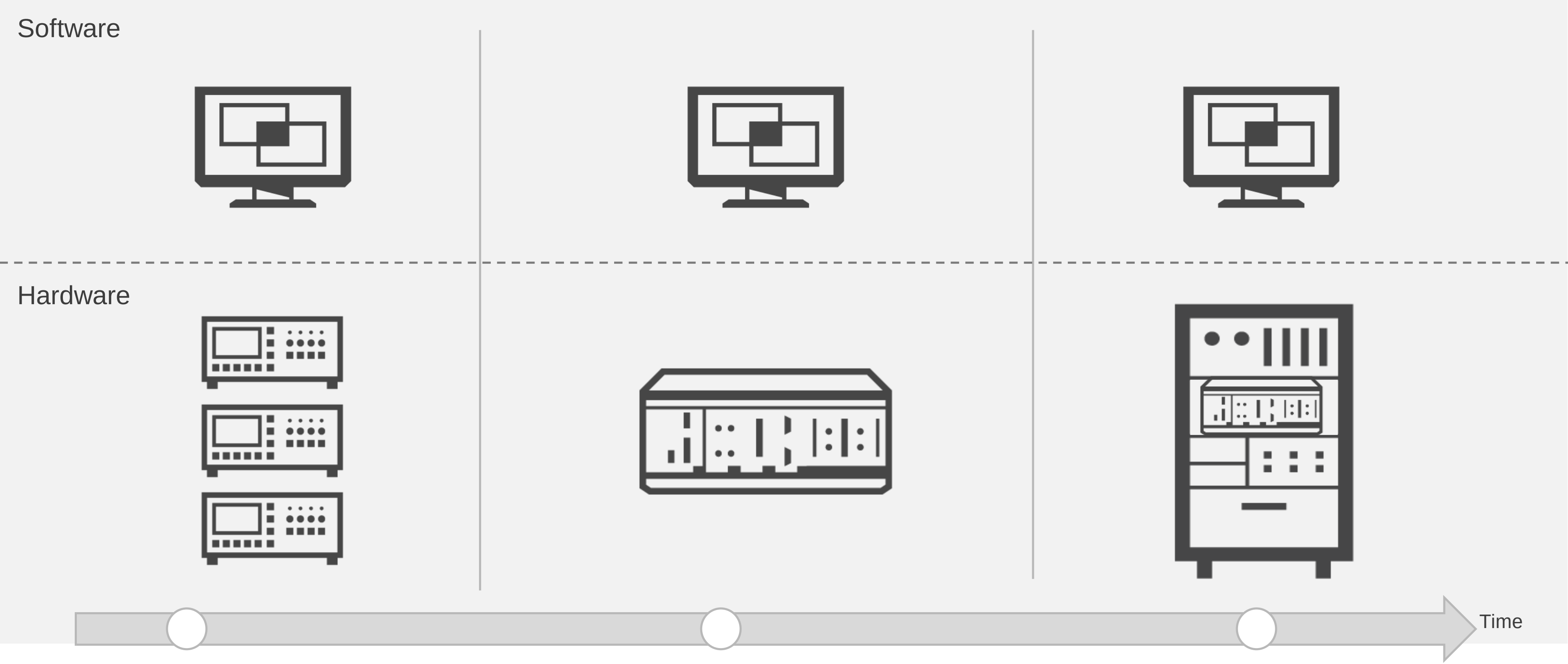
Test System Architecture & Importance of Software

Importance of Software



Importance of Software



Importance of Software

Separating Responsibilities

COMMON

Test Management Software

- Operator interface
- User management
- Test flow control
- Limit checking
- Parallel thread management
- Results processing

UNIQUE

Test Development Software

- Instrument control
- Stimulus
- Measurements
- DUT control
- DSP

Software for the Test System

Test Management Software

Development Environment

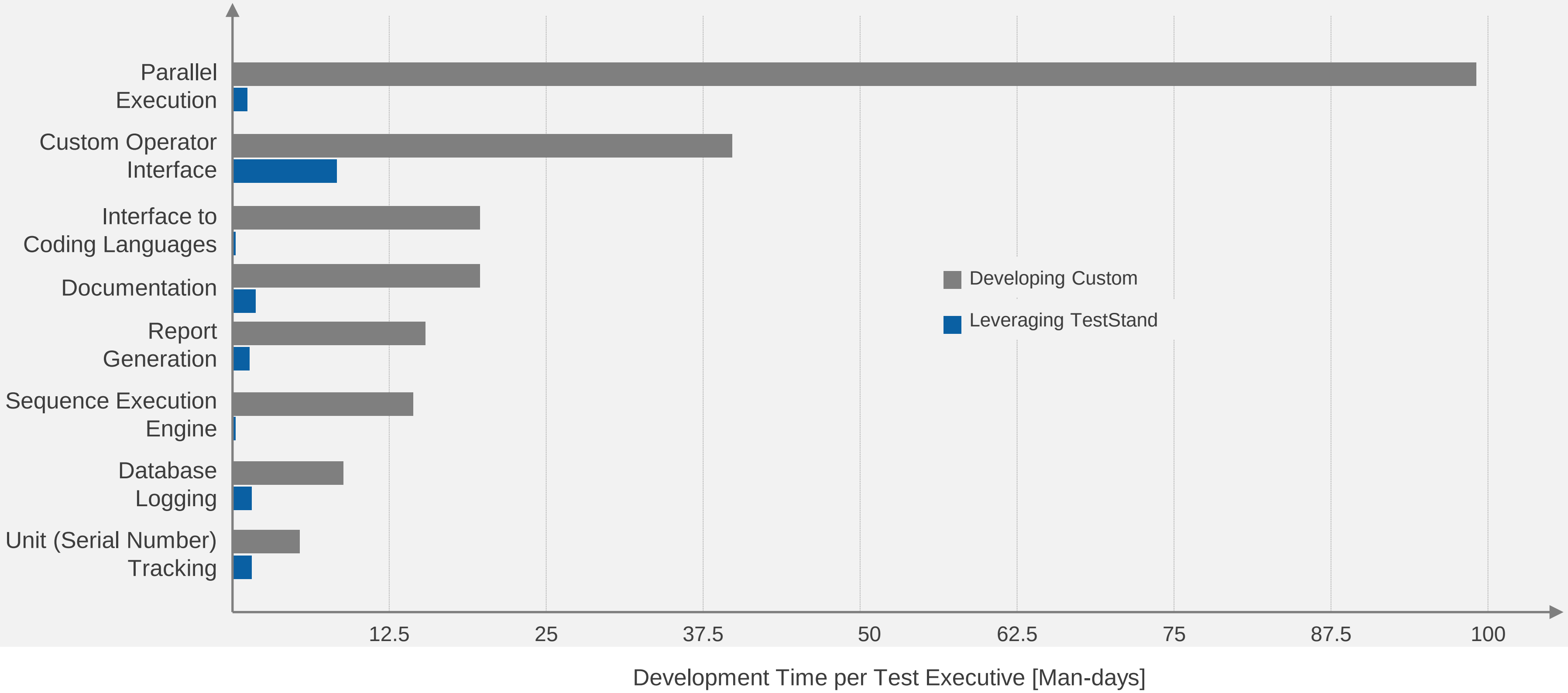
Programming APIs

Hardware Driver

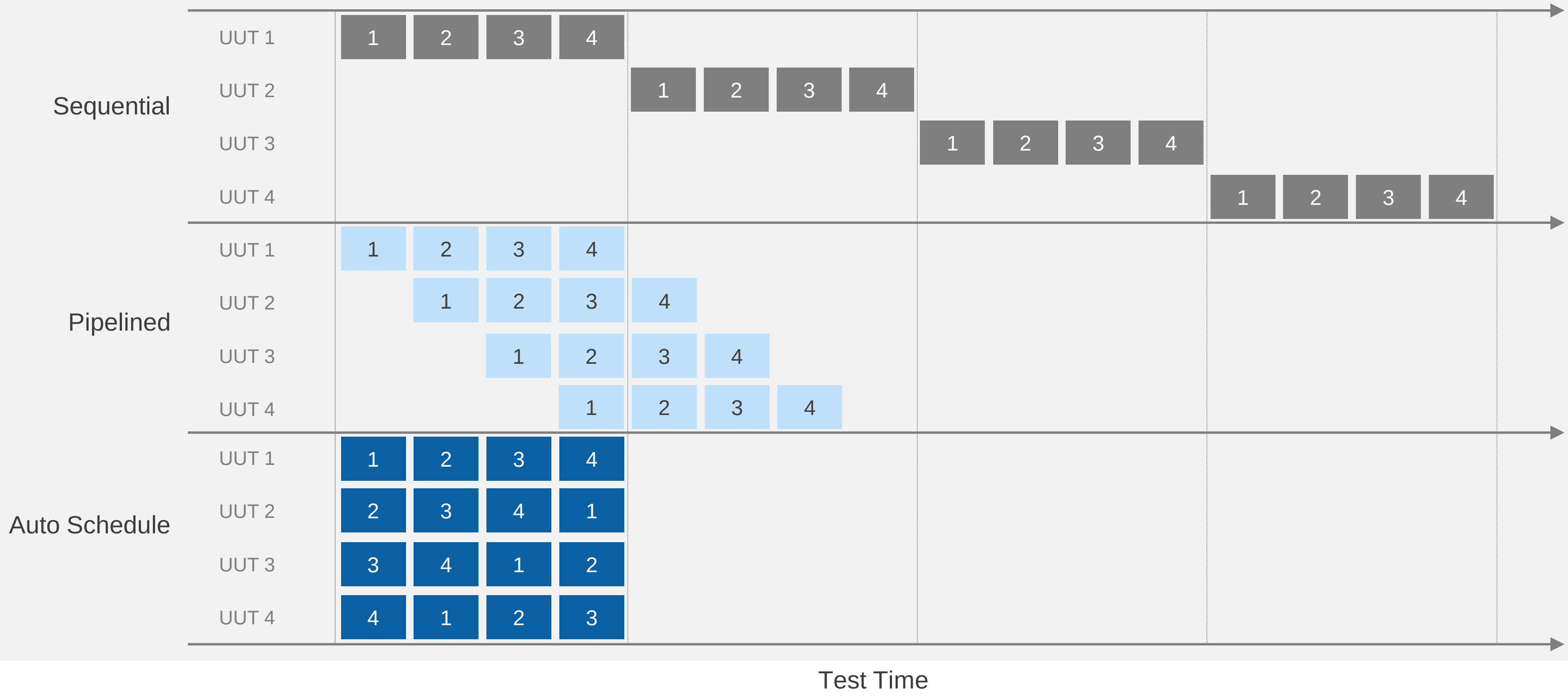
Software for the Test System

Test Management Software	TestStand
Development Environment	LabWindows/CVI, LabVIEW, MeasurementStudio
Programming APIs	C, C++, LabVIEW, Microsoft.NET, python
Hardware Driver	NI-DAQmx, NI-VISA, NI-RFmx, NI-SCOPE, NI-RIO

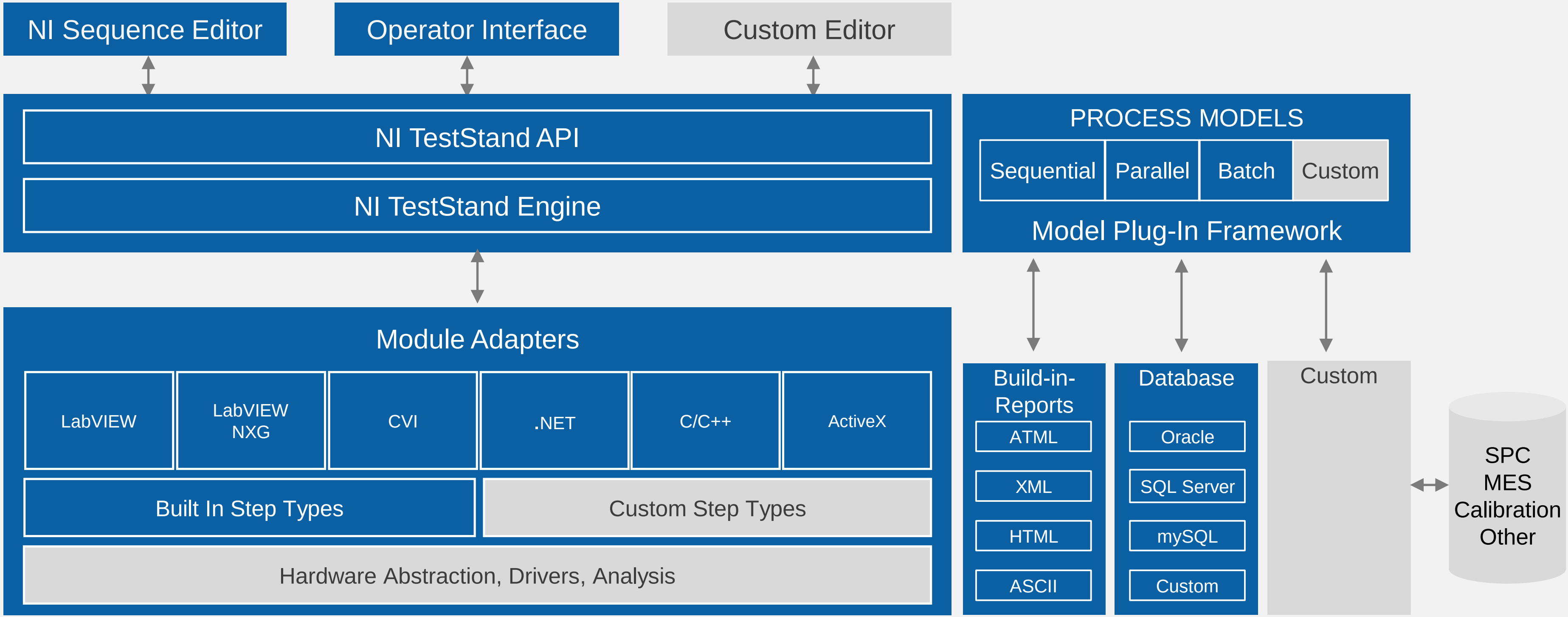
Increased Productivity with Test Management Software



Reducing Test Time with Parallel Device Test



TestStand Modular System Architecture



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Risk Versus Reward in Standardization

Is It Worth the Risk of Change?

- This is a big organizational challenge
- Great in theory but a long journey

Challenge of WHY

- Business pain points create the need for change
- Metrics must show results to sustain business sponsorship

Challenge of HOW

- Standardization treated as a purely technical exercise; fails to address the process, organization, and culture changes needed to drive adoption that leads to ROI

Challenge of WHAT

- Visions of “universal testers” rarely succeed and not all IP is suitable for reuse
- Careful assessment of what software, instrumentation, device families, and IP are needed to standardize and reuse in order to maximize adoption and ROI

Software Is Only Half the Battle: Common Platform Hardware

Technology

- Common hardware/software platform to enable reuse

Process

- Shared/accessible code repository
  - Instrument libraries
  - Shared templates and development tools
  - Development tools and methodologies
- Data aggregation and reporting tools

People

- Combined Center of Excellence (COE) with efficiency charter
- Structured training plan on automation tools
- Access to support/assistance on shared tools when needed

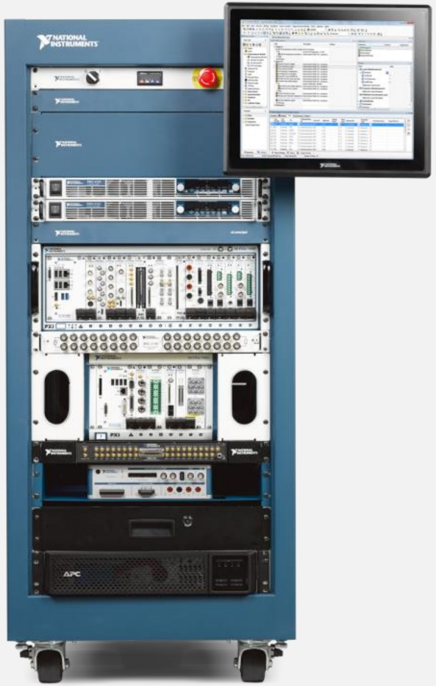
Requires initial forward investment, continuous sustaining of investment, and <u>support of business sponsors</u>

Common Test Development Steps

POTENTIAL FUTURE STATE

	Potential Future State
Finalize Test Hardware and Device Connectivity (DIB or Cabling)	Reduce setup/design time with standard configurations
Develop Test Code	Up to 50% reuse from characterization to production
Bring Up DUT	From weeks to days/hours
Take Measurement/Debug Code	Find bugs 2X faster
Capture, Analyze, and Correlate Data	From months to weeks

Case Study: Shared Test Platform

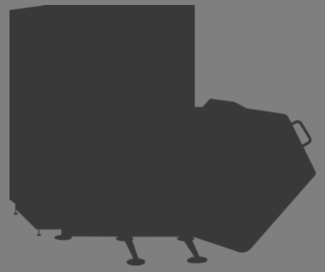


PXI-Based Common Test Platform for Characterization and Production	
Before	Two development efforts (Eval/Characterization and Final Test) with correlation effort between two hardware test platforms
After	Single development effort with NI software/hardware at the core of a common platform (no correlation required)
Impact	▪ >40% savings in engineering effort ▪ Foundation for future projects that will amplify savings

API Reuse

TRADITIONAL ATE

"Vendor knows best"



PLATFORM APPROACH

"Customer knows best"

Leverage Application Programming Interface (API) for ATE using STS Development	
Before	Translated product API from C to Visual Basic for the traditional ATE system; significant debug and frequent code realignment required
After	Share same product API across V&V, Applications Engineering (customer support), and production test on STS; ensures alignment across all functions
Impact	▪ >50% reduction in capital cost with STS ▪ >1 man-year engineering effort saved by reusing API; effort is amplified for follow-on projects

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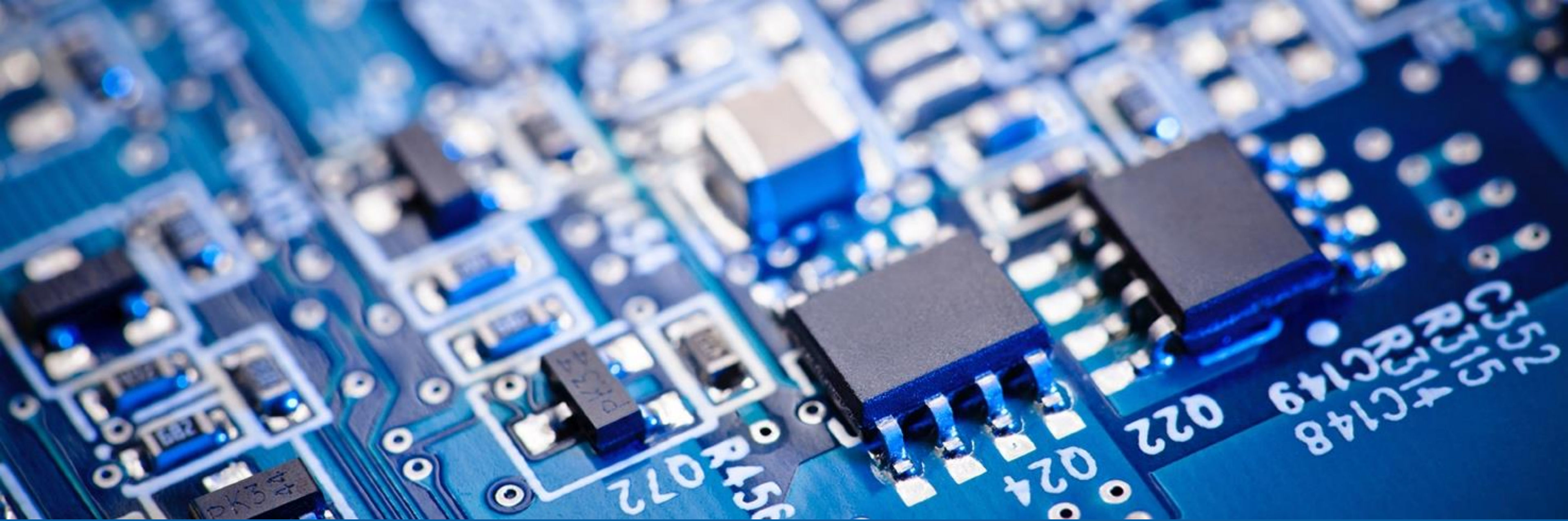


TestStand Provides the Framework to Texas Instruments $4 Billion Division

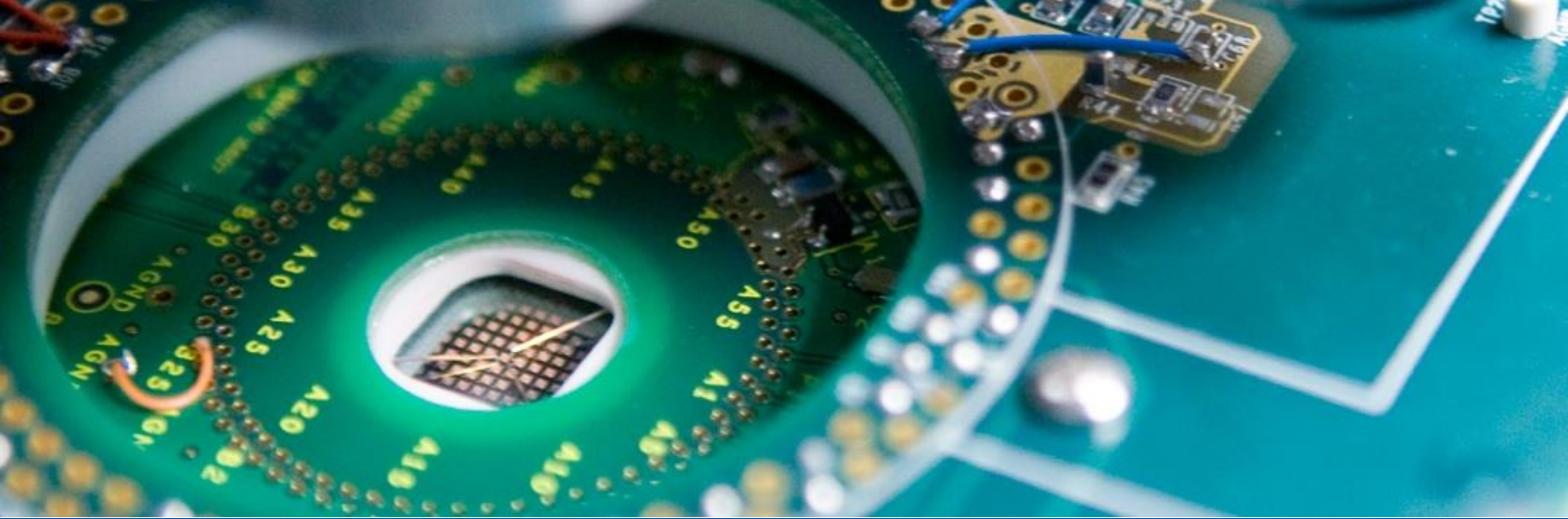
"By leveraging commercial off-the-shelf software technologies such as TestStand and LabVIEW, we achieved the level of commonality, maintainability, and reuse with our characterization platform to keep up with the design of new components."

—Marvin Landrum, Texas Instruments, Inc.

Automatic Bench Characterization of USB Transceivers

“Our setup is portable, can be deployed for system validation measurements, and has reduced bench characterization time from months to weeks with NI PXI modular instruments.”

— Bakkurudeen Ali Jahaya, ST-Ericssion Asia Pacific Pte Ltd



Performing On-Wafer Testing with LabVIEW, NI TestStand, and PXI

"Using LabVIEW and TestStand, we developed the characterization system from scratch in approximately four man-months."

— Sudhir Gopinath, Proteus Biomedical Inc.

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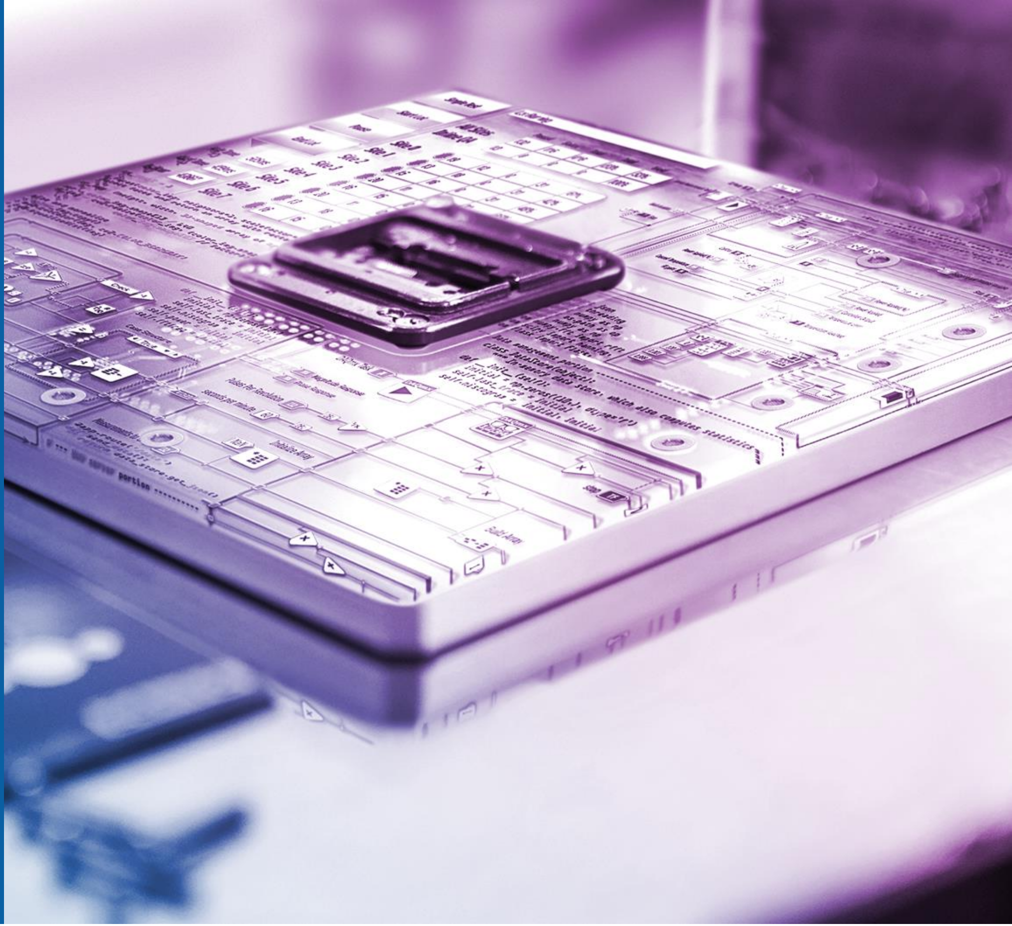
Introduction to the PXI Platform

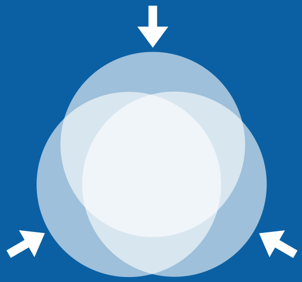
Smarter Test From
Characterization to Production



Tarek Safwan
Field Marketing, Semiconductor Test
National Instruments

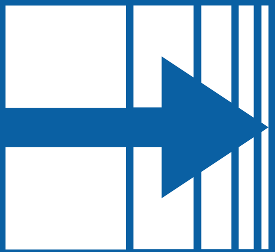
Unique Attributes of Smart Devices: Common Test Needs

CONVERGENCE



LOWER PRICE

RAPID CHANGE



More functionality

High reliability

Lowest cost

Short time to market

Boxes Are Throttling Innovation

- Fixed Functionality
- Outdated Processors
- Communication Latency
- Little Data Streaming
- Closed Software

The old, closed approach to test just isn’t smart;
it can’t keep pace with innovation.

Smarter Test System

- Open, Flexible Software
- Modular Hardware
- Vibrant Ecosystem
- “Customer Knows Best”

A smart test system is more than a fixed-functionality instrument; it is built for automation and customization.

Characteristics of the Stable PXI Platform

- Founded in 1997
- 60+ Vendors
- 2000+ Modules
- Latest Technology
- Growing Market Share

PXI Systems Alliance

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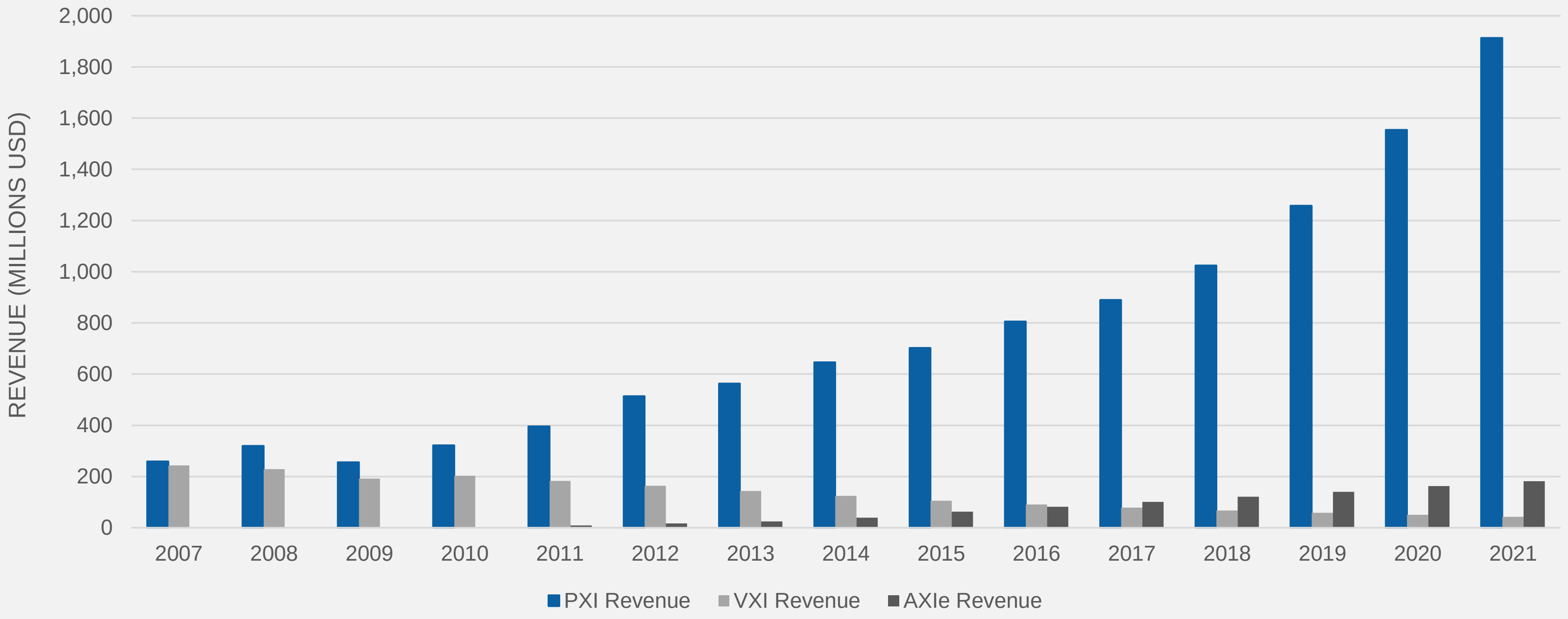
Continued Innovation in PXI Platform



Source: Frost & Sullivan

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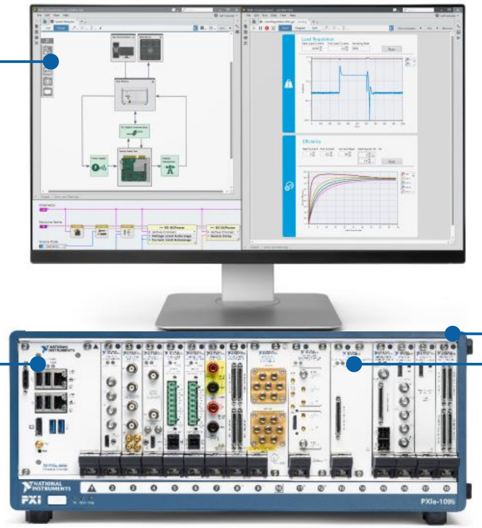
Anatomy of a PXI Test and Measurement System

Software

Test Management and Code Development
Code sequencing, database reporting, user management, operator interface, parallel execution, signal processing; LabVIEW, C/C++, .NET, Python

Timing and Synchronization

PXI Chassis
PCI Express Gen 3 throughput up to 24 GB/s, subnanosecond latency, P2P streaming, integrated triggering



Computer

PXI Embedded Controller
Windows and real-time OS options, Intel Xeon processing, peripheral ports, display output, integrated hard drive

Instrumentation

PXI Modules
DC to mmWave, oscilloscope, programmable power supply, switch/MUX, DMM, VSA, VSG, VST, AWG, SMU, DAQ

Architecture of an Automated Test System

SOFTWARE

Test Execution and Management

Test Development

Instrument Configuration and Debug

Instrument Drivers

HARDWARE

- Multicore Controllers
- Timing and Synchronization
- Test Cell Integration
- PXI Instrumentation
- Condition Monitoring
- Third-Party Instrumentation

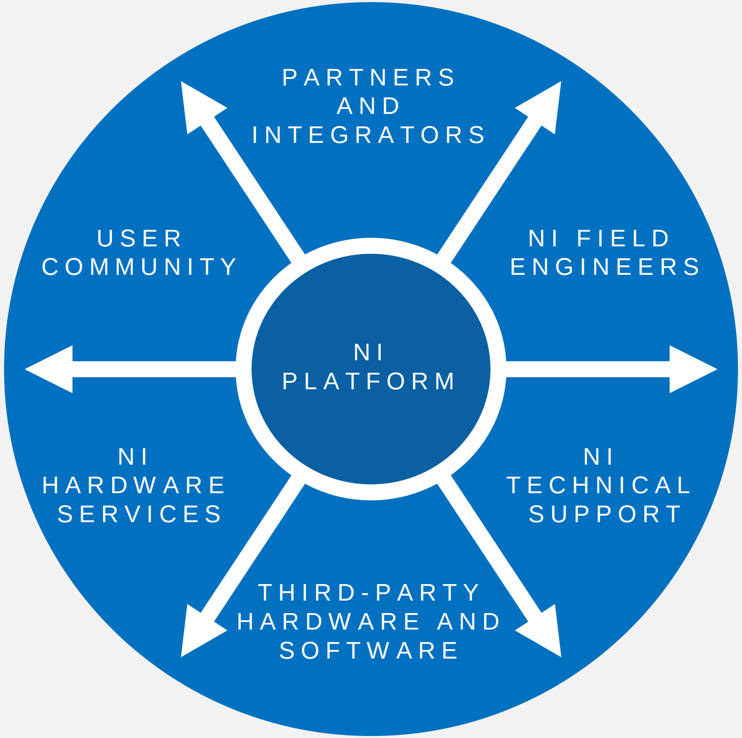
Fixture/Mass Interconnect

An Ecosystem Built on the NI Platform

300k+
Users

30+
Service Centers

350+
Software Toolkits



1000+
Partners

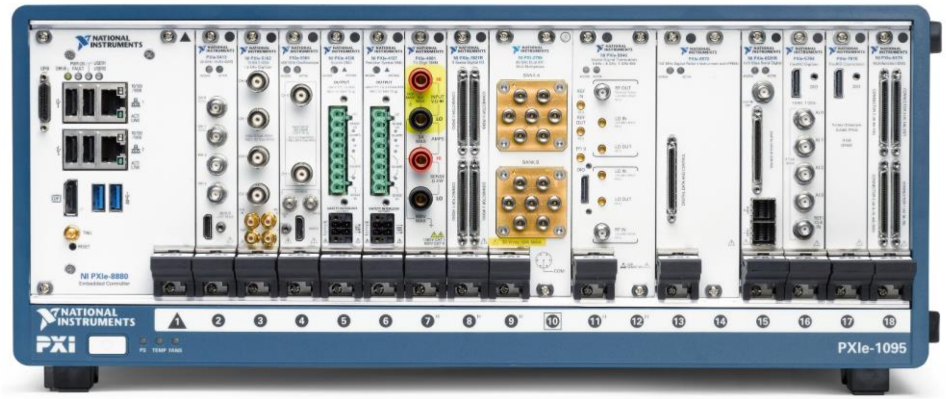
700+
Field Engineers

700+
Support Engineers

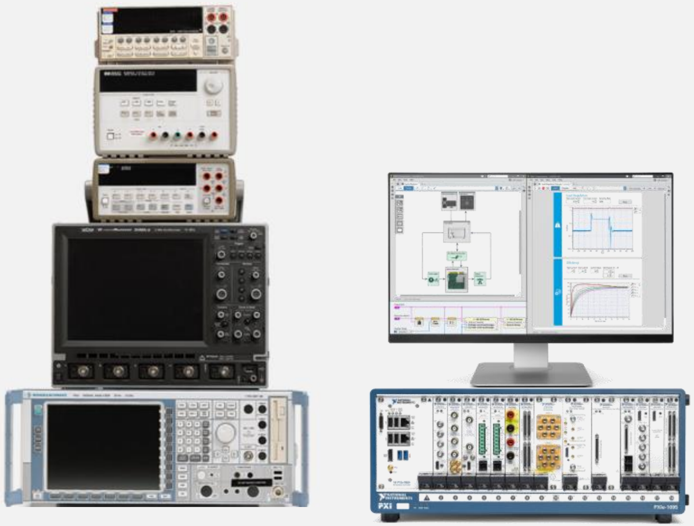
PXI Integrates All Instrumentation Protocols

Broad Modular Instrumentation Portfolio

DAQ and Control	Instrumentation	Interfaces
Multifunction I/O	Oscilloscopes	GPIB, USB, LAN
Counter/Timer/Clock	High-Speed Digital I/O	RS232/RS485
Digital I/O	DMM and SMU	CAN, LIN, DeviceNet
Analog Input/Output	Signal Generators	SCSI, Ethernet
Vision and Motion	Switching	VXI/VME
FPGA/Reconfigurable I/O	RF Analyzers and Generators	Boundary Scan/JTAG



Advantages of PXI Instrumentation



- High Measurement Quality
- Low Latency and High Throughput
- Software-Defined Functionality
- Integrated Timing and Sync
- High-Performance Processing
- Reduced Size, Weight, and Power
- Complete Instrumentation Portfolio

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Industry-Leading Test and Measurement Platform

PXIe-5162
4 ch, 1.5 GHz,
10-bit digitizer

PXI-4081
7½-digit, 1 kV
precision DMM

PXIe-5668
26.5 GHz VSA with
765 MHz bandwidth

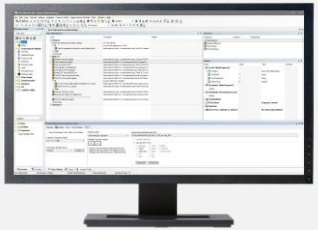
PXIe-4135
precision system SMU
10 fA sensitivity

PXIe-5840
6 GHz VST with
1 GHz bandwidth

PXIe-1095
PXI chassis
24 GB/s throughput

PXIe-8880
PXI Express controller
8-core Intel Xeon

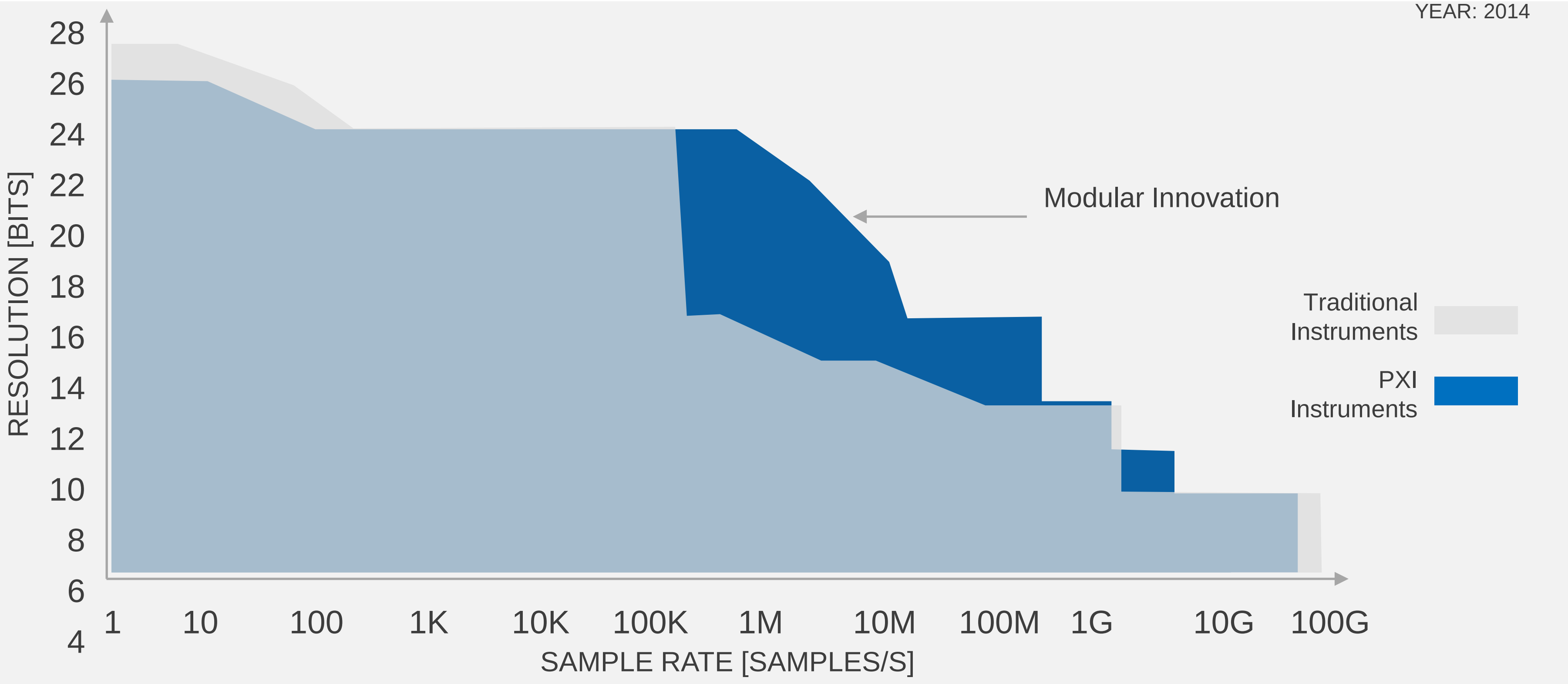
LabVIEW
system design
software



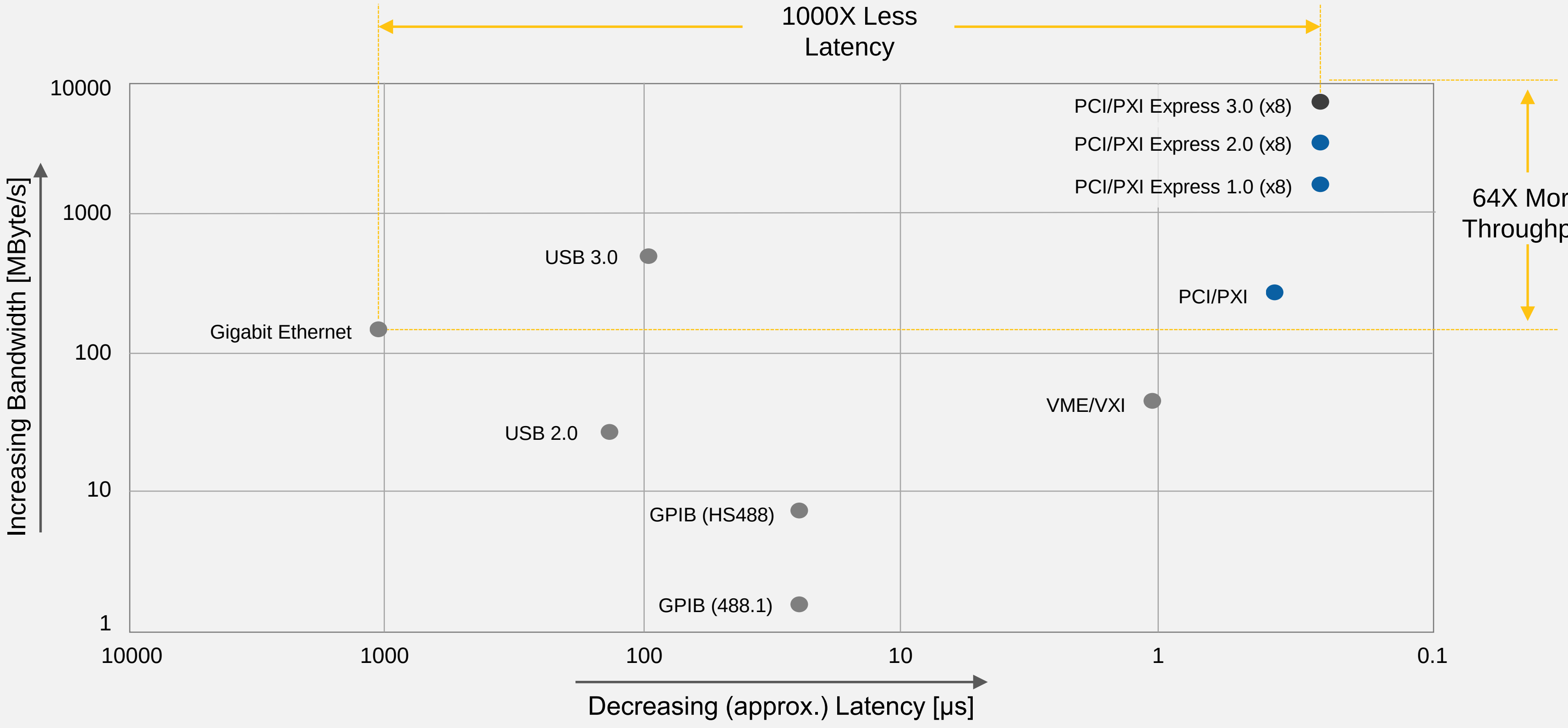
TestStand
test management
software

PXIe-2543
6 GHz, 8 ch, solid-state
multiplexer

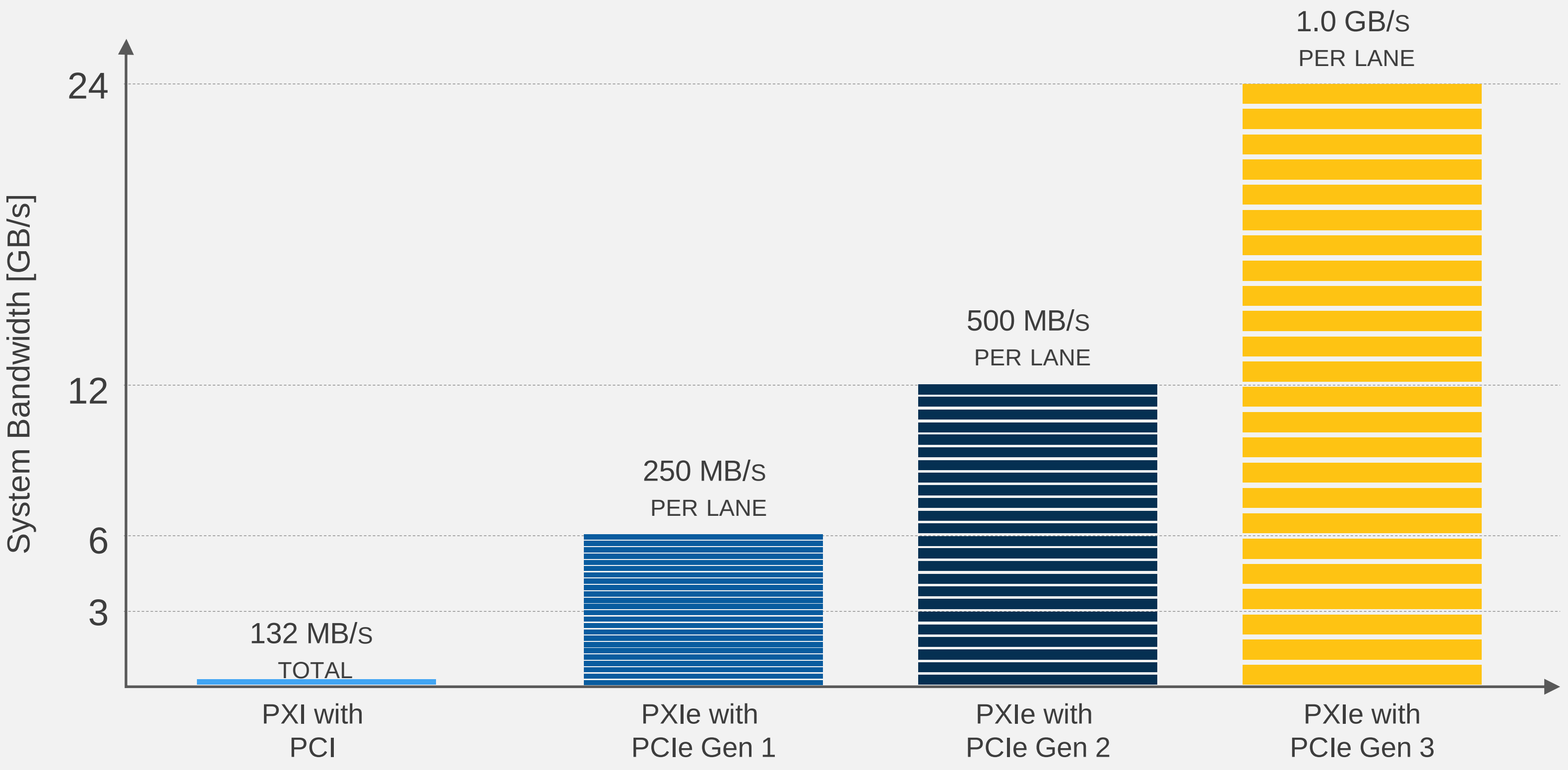
Trusted Measurement Quality



High Throughput and Low Latency With PXI



Continually Increasing System Bandwidth



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PXIe-1095

Industry's first chassis with 82 W of power and cooling in every slot

- 18-slot, 24 GB/s system bandwidth
  - 5 PXI Express hybrid slots, 12 PXI Express only (including one system timing slot)
- 2 hot-swappable, easily serviceable, 1,200 W power supplies
- 2 distinct, software-selectable cooling profiles
- Significant reduction in fan noise in 38 W profile
- Optional timing and synchronization upgrade
  - Built-in OCXO, external clock, and trigger routing

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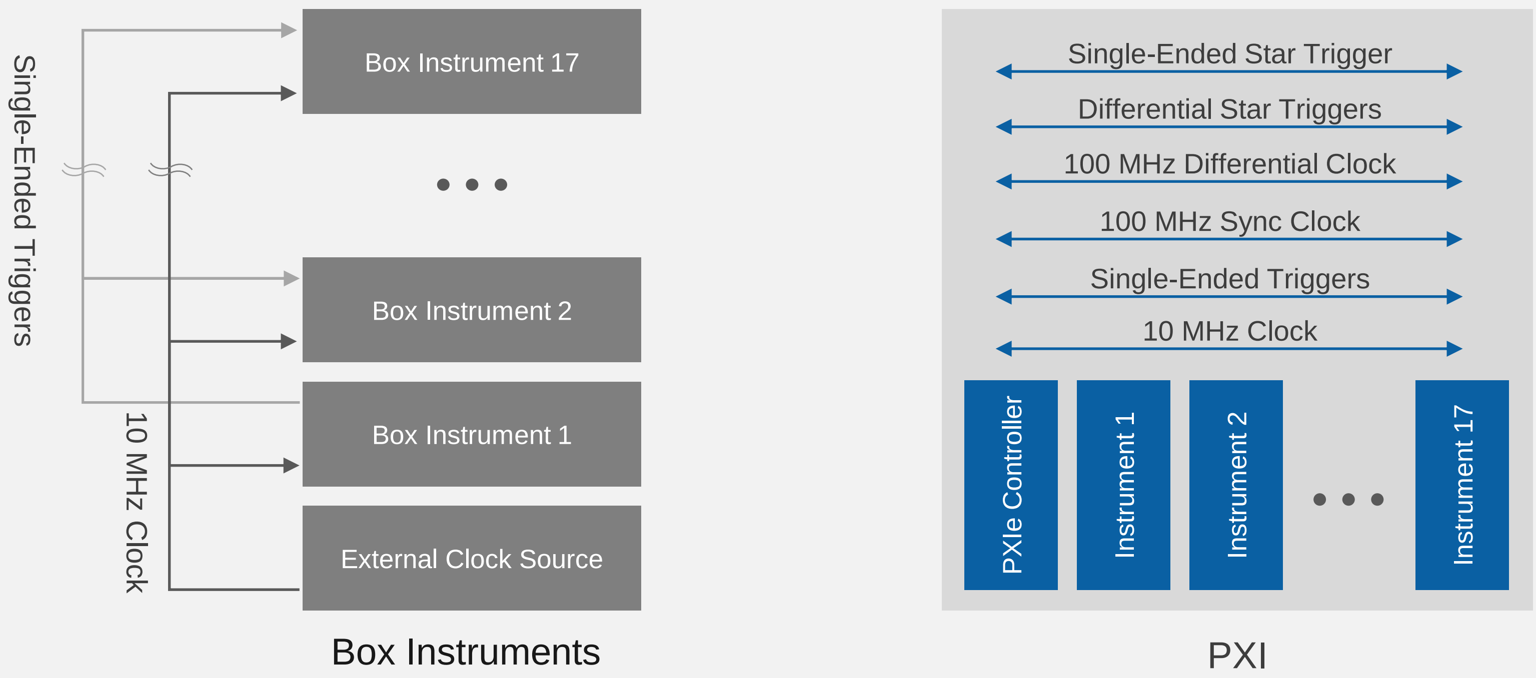
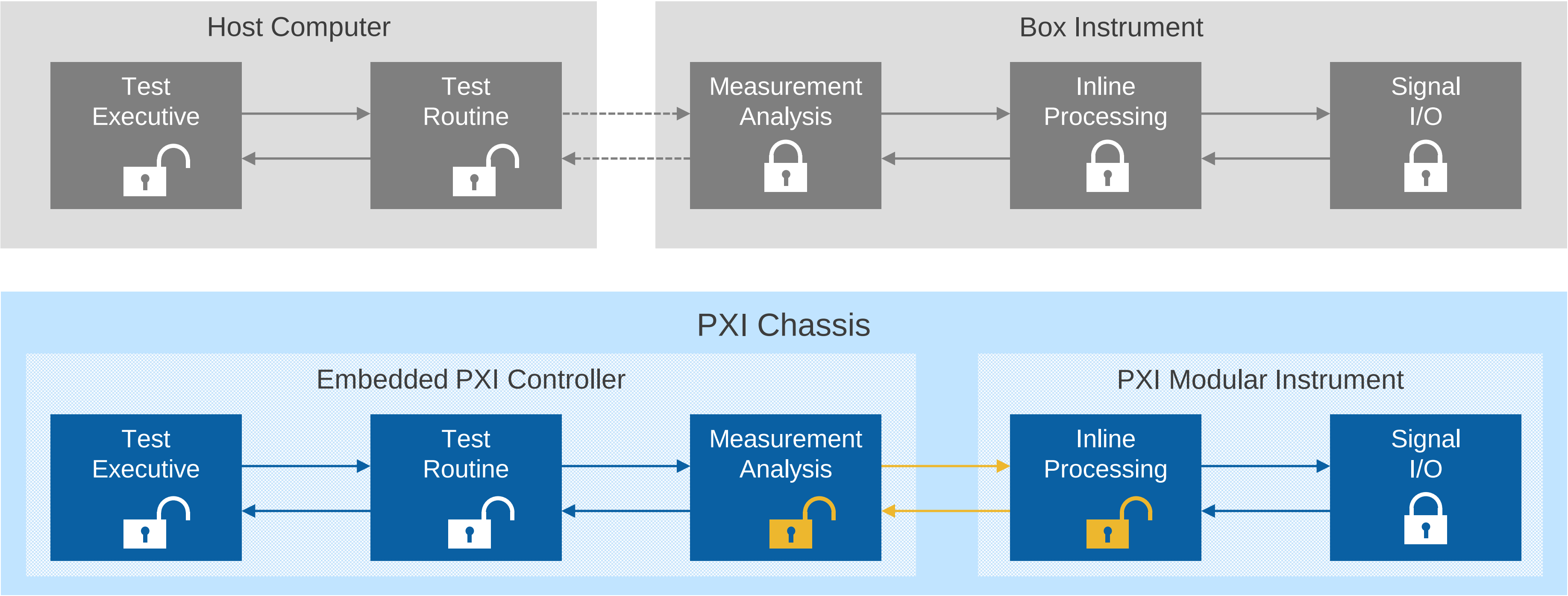
Advanced Timing and Synchronization With PXI



Highest Flexibility With Software-Defined Instruments



Software-Designed Instruments

PXIe-5668
26.5 GHz, >765 MHz BW
RTBW vector signal analyzer

PXIe-5840
6 GHz VST with
1 GHz bandwidth

PXIe-5624
2 GS/s, 12-bit
IF digitizer

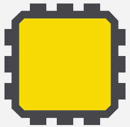
PXIe-6591/92
12.5 Gbps, 4–8 ch.
high-speed serial

PXIe-5170/71/72
250 MS/s, 14-bit, 4–8 ch.
oscilloscope

PXIe-7976
3.5 GB/s streaming
K410T K7 FlexRIO

"Fully functional instrument out of the box"

Customize functionality with



LabVIEW FPGA

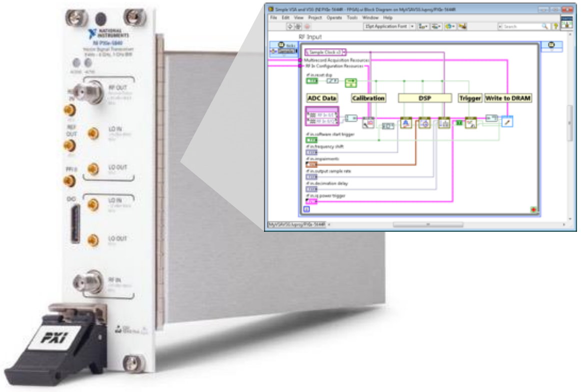
Second-Generation Vector Signal Transceiver

FEATURES AT A GLANCE

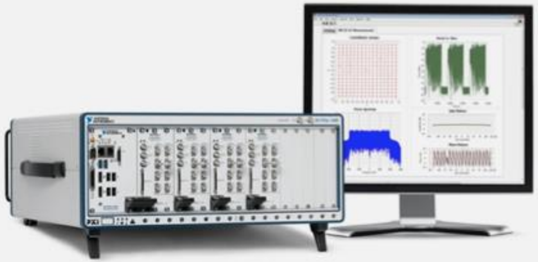
- User-programmable FPGA with LabVIEW
- 1 GHz of instantaneous bandwidth for advanced digital predistortion test and wideband signals
- Excellent accuracy enables measurement of 802.11ax error vector magnitude performance of -50 dB
- FPGA enables measurement speeds up to 10X faster than traditional instrumentation
- Small size and tight synchronization allow for up to 8x8 MIMO configuration in a single 18-slot chassis

APPLICATION AREAS

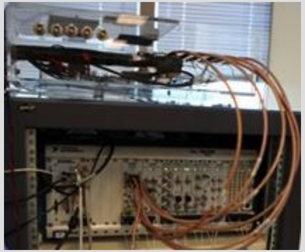
- Wireless test
- Semiconductor test
- Automotive radar

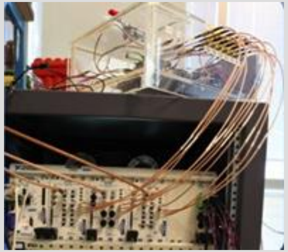


Qualcomm Reduces Test Times



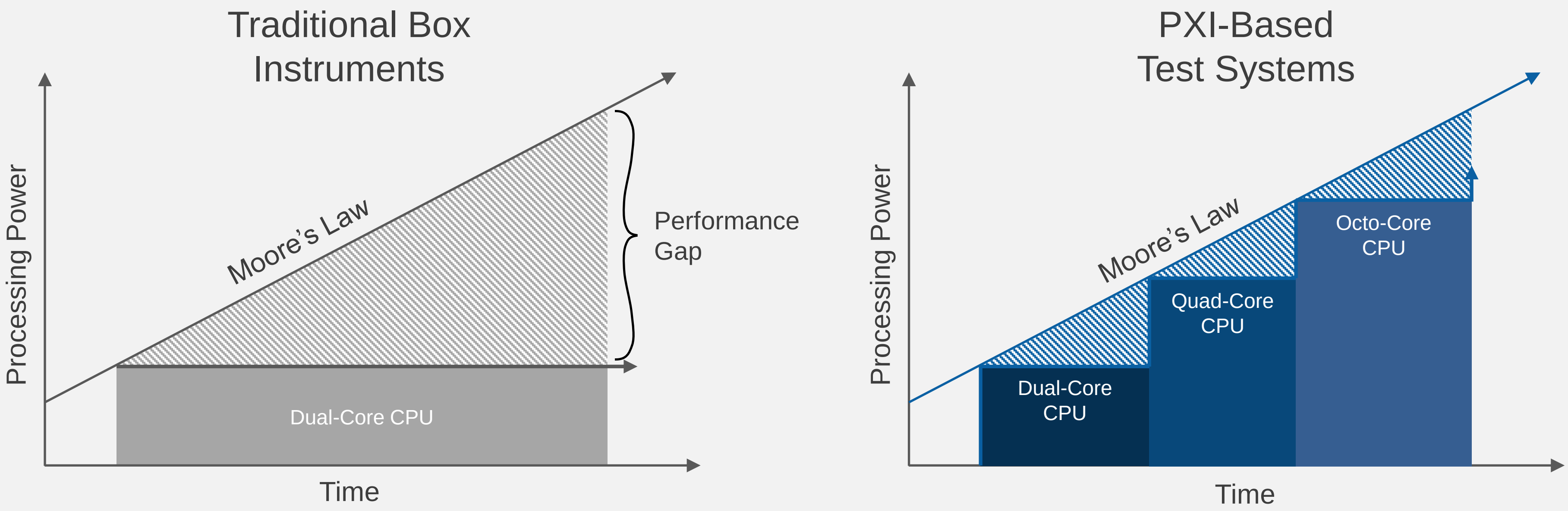
"We improved test speeds by more than 200X compared to traditional rack-and-stack instruments while significantly improving test coverage."





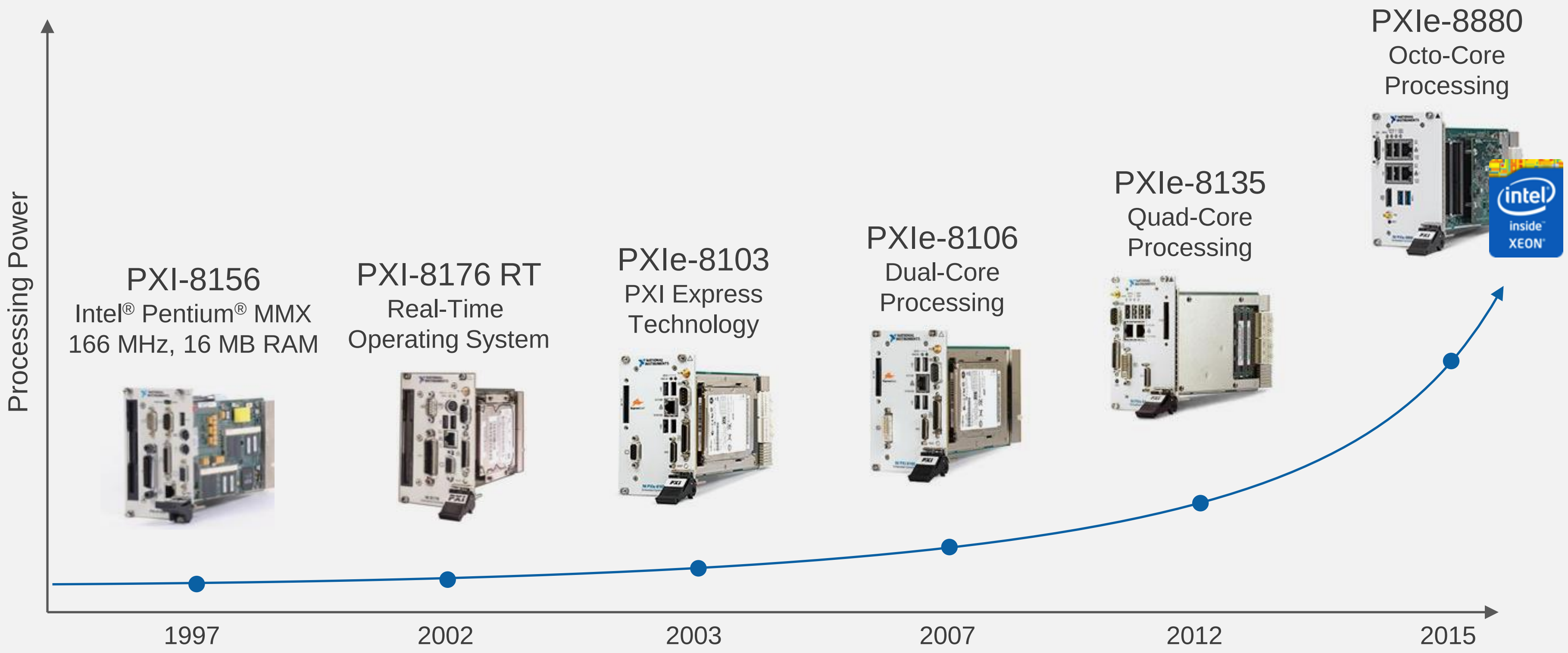
	Previous	PXI Phase 1	PXI Phase 2
Technology	Traditional Box Instrumentation	NI PXI RF Instrumentation	NI Vector Signal Transceiver
Year	Early 2000s	2007	2012
Test Time Reduction	1X	10X	200X
WLAN Protocols Tested	802.11a 802.11b 802.11g	802.11a 802.11b 802.11g 802.11n	802.11a 802.11b 802.11g 802.11n 802.11ac

Reducing Test Times With Latest CPUs and FPGAs



NATIONAL INSTRUMENTS™

Industry-Leading NI PXI Controller Portfolio



NATIONAL INSTRUMENTS

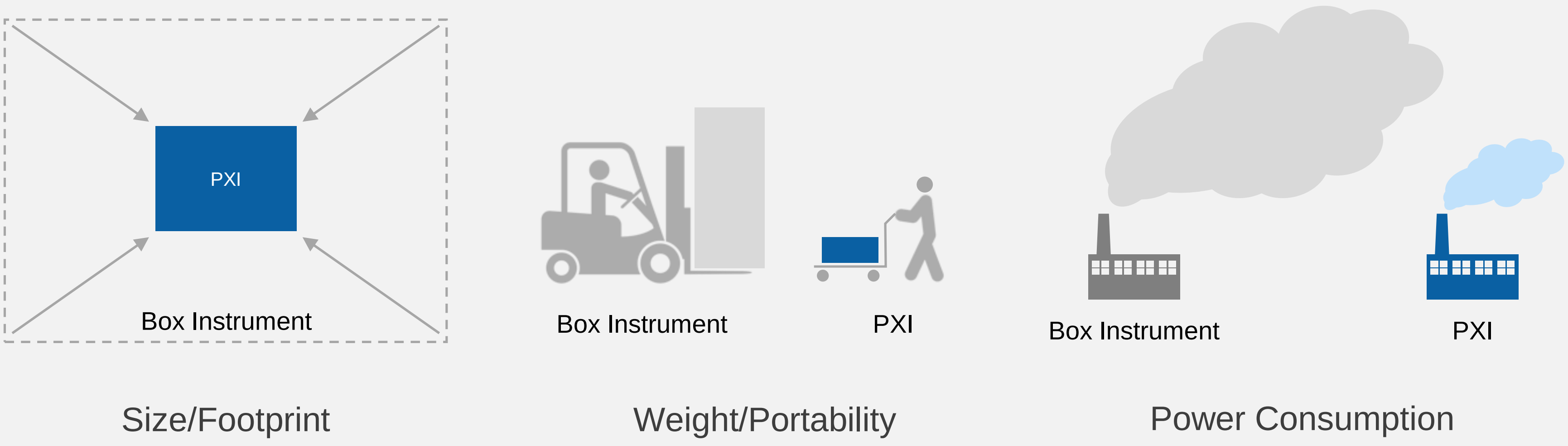
PXIe-8880 Embedded Controller

Embedded controller with Intel Xeon technology

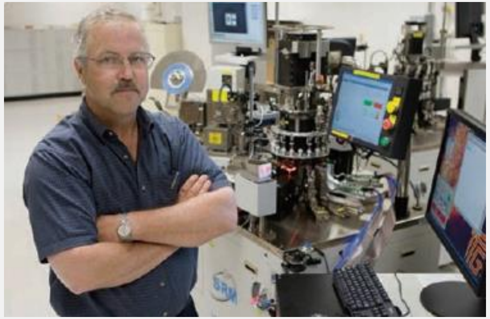
- Intel® Xeon® E5-2618L v3 processor
- 2.3 GHz (base) and 3.4 GHz (Turbo Boost)
- 8 physical and 16 logical CPU cores
- 8 GB DDR4 1866 MHz RAM (standard); 24 GB max
- Up to 24 GB/s system bandwidth (each direction)
- 240 GB, 1.8 in. SSD hard drive
- Windows 7 64-bit or LabVIEW Real-Time OS
- PXI Express with PCI Express Gen 3 technology

NATIONAL INSTRUMENTS

Reduced Overhead With PXI Form Factor



Analog Devices Reduces MEMS Test Cost



ANALOG DEVICES

“Using PXI and LabVIEW, we were able to test our MEMS devices at a fraction of the cost, weight, power consumption, and footprint of our previous ATE system.”

	Previous ATE	PXI System	Reduction
Cost	$450k	$40k	11X
Footprint	277 ft^3	1.75 ft^3	158X
Weight	4000 lb	60 lb	66X
Energy	10 kW	0.6 kW	16X

Agenda

Time	Topic	Presenter	Demo
9:00	**Welcome and Introductions**		
9:15	**Lower the Cost of Test While Improving Time to Market with Better Cross-Functional Workflows**	Joshua Young	No
10:00	**Introduction to the PXI Platform**	Tarek Safwan	No
10:30	**Using a Modular Platform for Mixed-Signal Semiconductor Characterization** • Use InstrumentStudio™ to save project configurations, export measurement results, monitor instruments and perform interactive debugging • See how the digital capability of semiconductor ATE systems can be replicated with a lab-friendly footprint • Live demonstration of DUT characterization using modular instruments	Tarek Safwan	Yes
12:00	**Lunch/Networking**		
13:00	**Using a Modular Platform for RFIC Semiconductor Characterization**	Mher Minasyan	Yes
13:30	**RF Measurement Optimization with RFmx**	Mher Minasyan	Yes
14:15	**Beyond Bluetooth 5**	Mher Minasyan	Yes
14:45	Wrap-up and summary	All	

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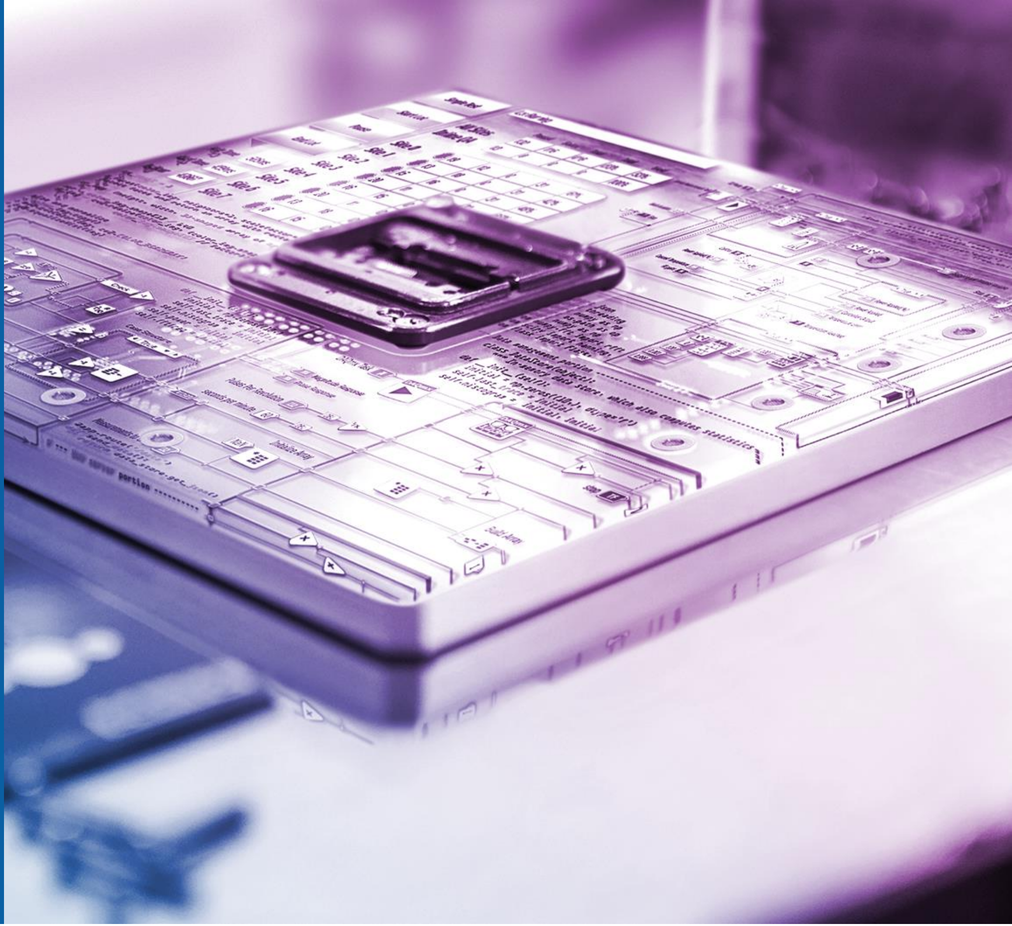
Using a Modular Platform for Mixed-Signal Semiconductor Characterization

Smarter Test From
Characterization to Production

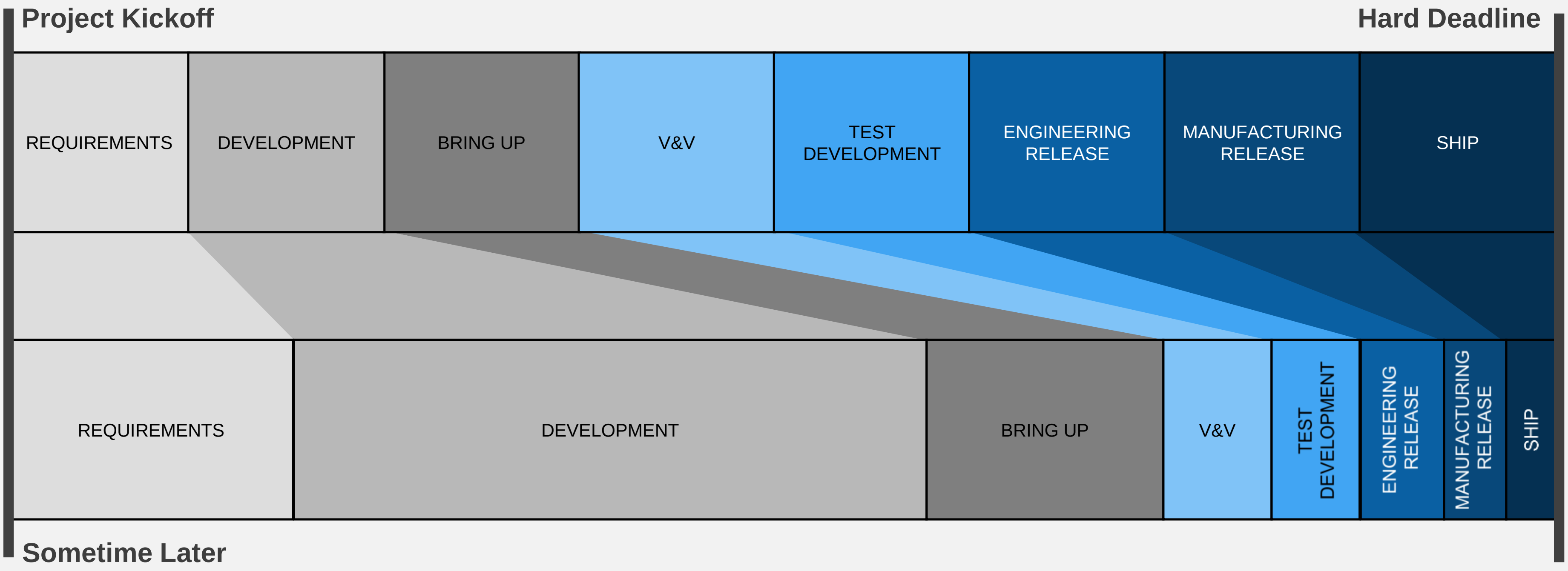


Tarek Safwan
Field Marketing, Semiconductor Test
National Instruments

NATIONAL INSTRUMENTS

ni.com/semiconductor

Does this ever happen to your projects?



Broad Modular Instrumentation Portfolio

DAQ and Control

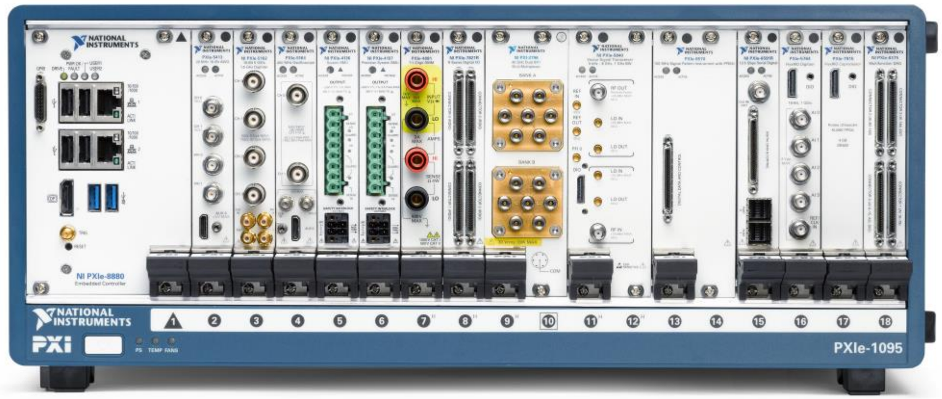
- Multifunction I/O
- Counter/Timer/Clock
- Digital I/O
- Analog Input/Output
- Vision and Motion
- FPGA/Reconfigurable I/O

Instrumentation

- Oscilloscopes
- High-Speed Digital I/O
- DMM and SMU
- Signal Generators
- Switching
- RF Analyzers and Generators

Interfaces

- GPIB, USB, LAN
- RS232/RS485
- CAN, LIN, DeviceNet
- SCSI, Ethernet
- VXI-VME
- Boundary Scan/JTAG



NATIONAL INSTRUMENTS

PXI Instrumentation for Mixed-Signal IC Test

NI Source Measure Units (SMUs)

- Broad IV range up to 200 V and 3 A (20 W DC)
- Pulse up to 10 A (500 W)
- Current resolution to 10 fA
- Max sampling to 1.8 MS/s
- NI SourceAdapt technology for fast settling in presence of capacitive loads
- Best-in-class channel density

NI Digital Pattern Instrument

- ATE-class digital (with PPMU) in PXI
- Out-of-the-box Digital Pattern Editor software for configuration, interactive tests, and debugging
- Time sets, drive formats, opcodes, source and capture, history RAM, Shmoo

Other Instrumentation

- General-purpose analog and digital I/O for AC measurements and peripheral control
- General-purpose power supplies for peripherals
- Arbitrary waveform generators and oscilloscopes

Demo Workflow

Initial Bring Up

- Power on the device, and confirm operation
- Establish digital communication, and confirm digital commands are being sent correctly
- Perform a manual test

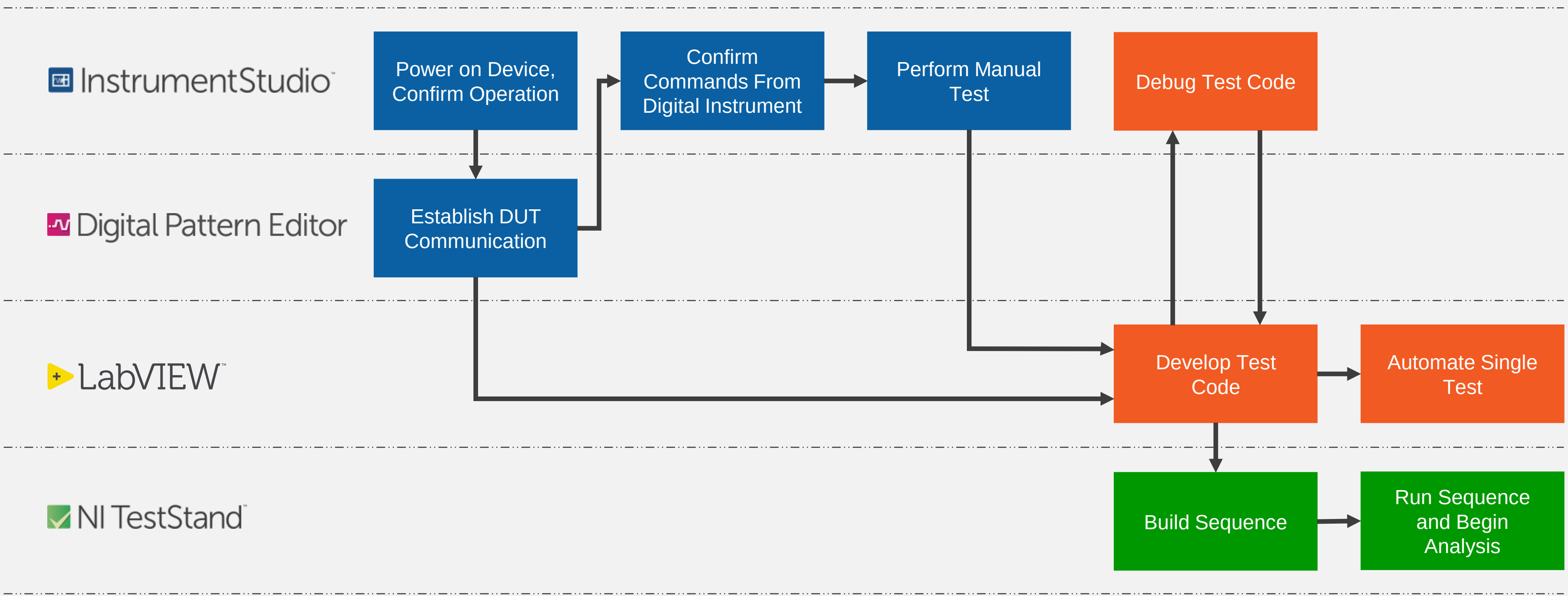
Code Module Development & Debug

- Develop code modules
- Debug code modules
- Automate individual code modules

Test Sequence Development & Deployment

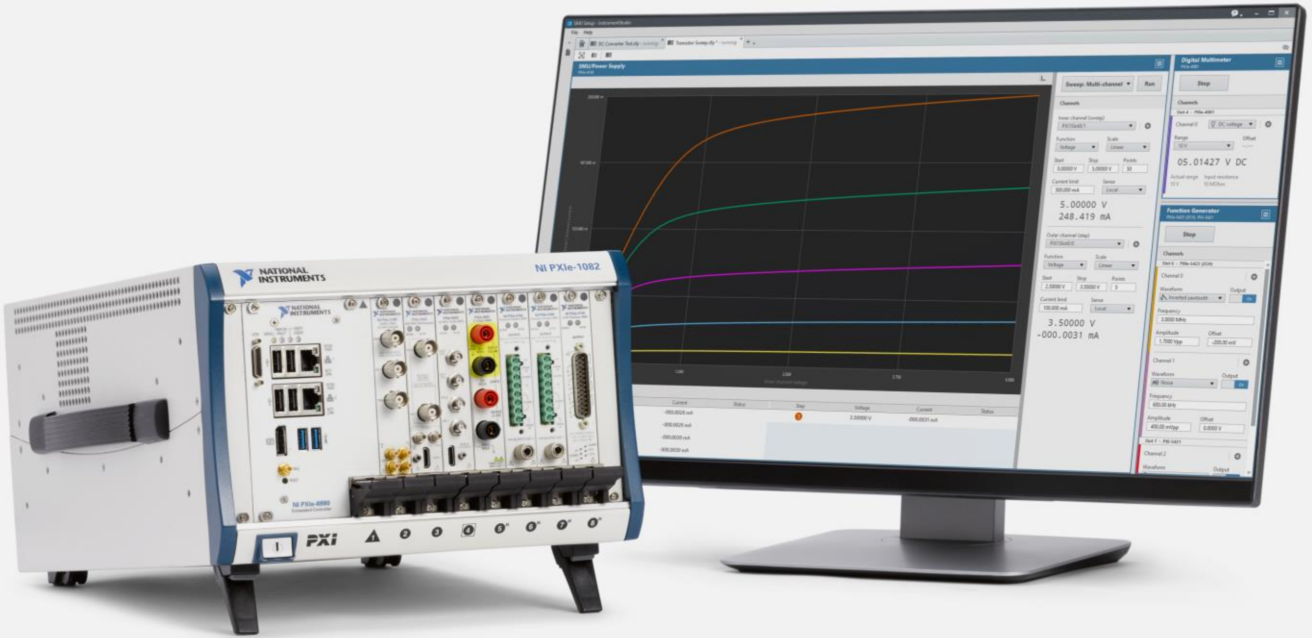
- Build a test sequence to automate all code modules
- Run sequence, and begin data analysis

Demo Workflow



What is InstrumentStudio and why is it relevant to me?

It is all about adding an Integrated UI to the PXI Platform



NATIONAL INSTRUMENTS™

InstrumentStudio™

Next-Generation Soft Front Panels for NI PXI Modular Instruments

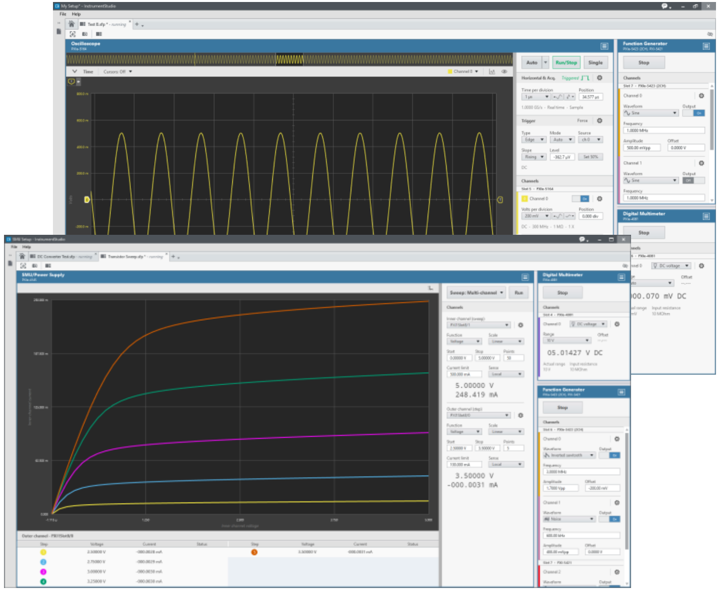
Access all your instruments in a single application
Take advantage of high-resolution monitors rather than small, integrated displays

Capture screenshots and export data
Store screenshots and measurement results from *all* your instruments with a single click

Share projects with colleagues and between systems
Use your projects to store your UI layout and instrument configuration for instant repeatability

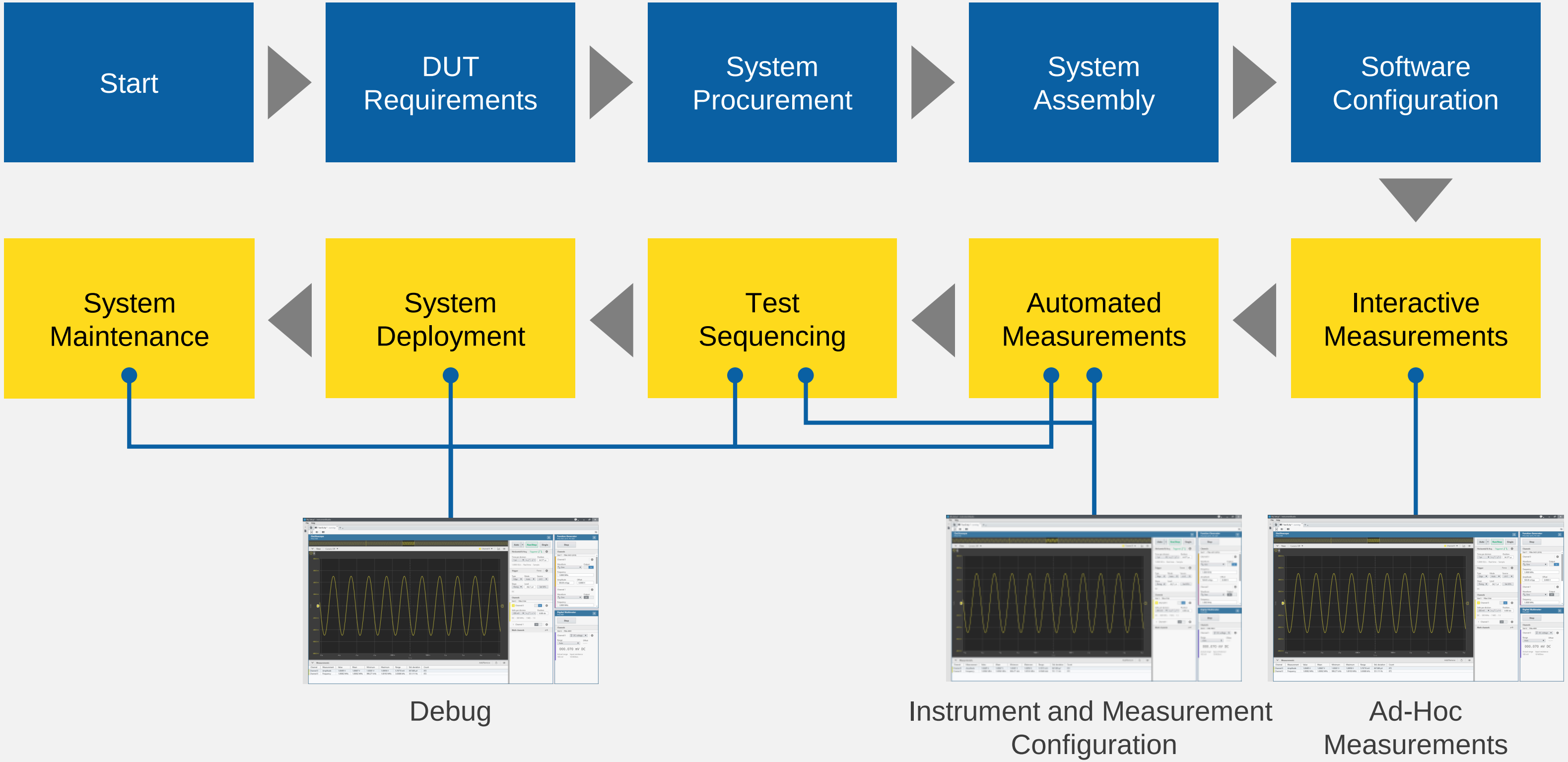
Export configurations for programmatic use
Minimize code development and guarantee measurement correlation

Monitor and debug automated test systems
Pause test sequences for debug or simply monitor your instruments while they are running



NATIONAL INSTRUMENTS™

Interactive Measurements in an Automated Workflow



InstrumentStudio™ 2018

Oscilloscopes, AWGs and FGens, DMMs, SMUs, and Power Supplies

Enhanced interactive use

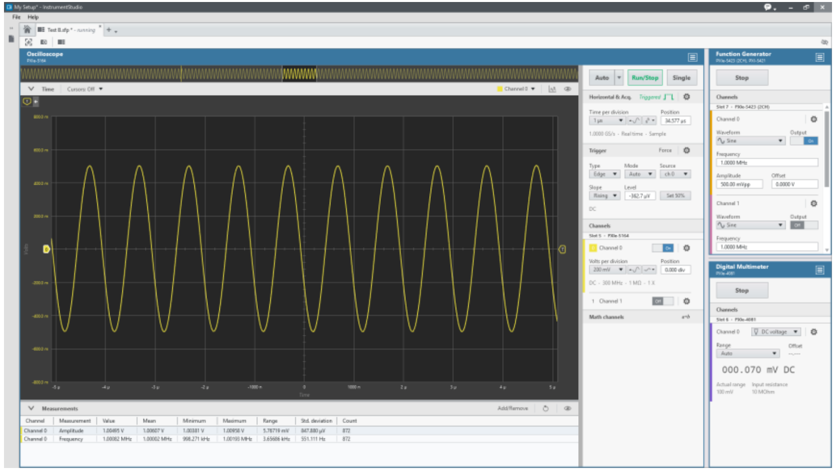
- Familiar but modern UI and UX with common functionality across instrument types
- Multi-instrument tabbed interface
  - Multidevice channel expansion within an SFP
  - One or many instruments per tab
  - Multiple tabs and multiple screens per instance
- Export data and screenshots
  - PNG, TDMS, clipboard
- Save UI configuration and share across systems

Streamlined transition from interactive to automated measurements

- Export instrument configuration for programmatic use

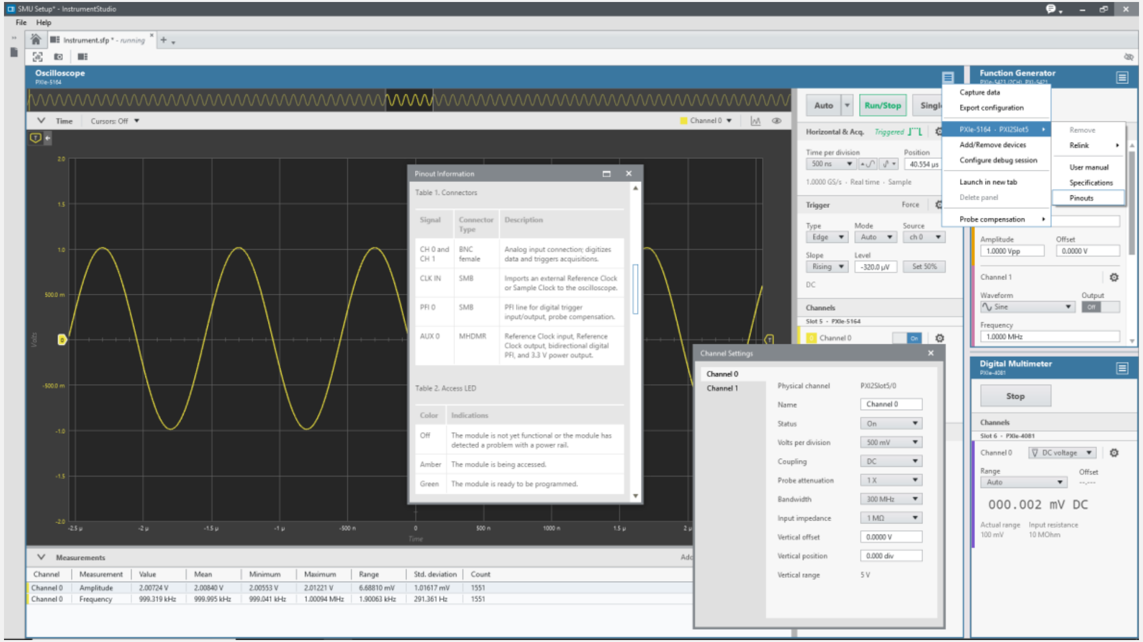
Simplified automated test system debug

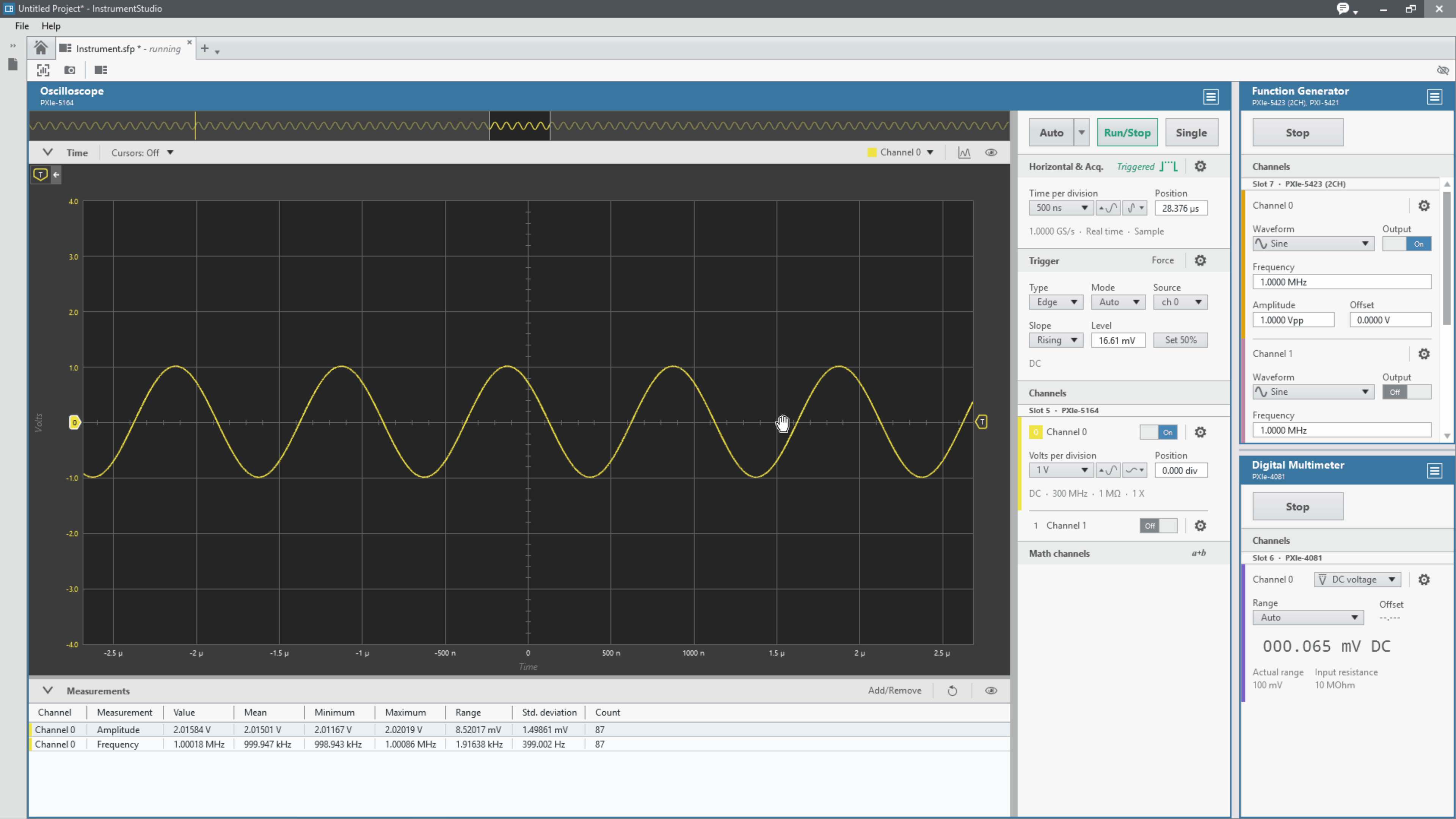
- Debug driver session—monitor and control



Oscilloscope: Configuration and Measurements

View device specifications and pinout from within the environment.




Untitled Project* - InstrumentStudio
File
Help
Instrument.sfp * - running
Oscilloscope
PXIe-5164
Time
Cursors: Off
Channel 0
Volts
Time
4.0
3.0
2.0
1.0
-1.0
-2.0
-3.0
-4.0
-2.5 µ
-2 µ
-1.5 µ
-1 µ
-500 n
0
500 n
1000 n
1.5 µ
2 µ
2.5 µ
Auto
Run/Stop
Single
Horizontal & Acq.
Triggered
Time per division
500 ns
Position
28.376 µs
1.0000 GS/s · Real time · Sample
Trigger
Force
Type
Edge
Mode
Auto
Source
ch 0
Slope
Rising
Level
16.61 mV
Set 50%
DC
Channels
Slot 5 · PXIe-5164
Channel 0
On
Volts per division
1 V
Position
0.000 div
DC · 300 MHz · 1 MΩ · 1 X
Channel 1
Off
Math channels
a+b
Measurements
Add/Remove
Channel
Measurement
Value
Mean
Minimum
Maximum
Range
Std. deviation
Count
Channel 0
Amplitude
2.01584 V
2.01501 V
2.01167 V
2.02019 V
8.52017 mV
1.49861 mV
87
Channel 0
Frequency
1.00018 MHz
999.947 kHz
998.943 kHz
1.00086 MHz
1.91638 kHz
399.002 Hz
87
Function Generator
PXIe-5423 (2CH), PXI-5421
Stop
Channels
Slot 7 · PXIe-5423 (2CH)
Channel 0
Waveform
Sine
Output
On
Frequency
1.0000 MHz
Amplitude
1.0000 Vpp
Offset
0.0000 V
Channel 1
Waveform
Sine
Output
Off
Frequency
1.0000 MHz
Digital Multimeter
PXIe-4081
Stop
Channels
Slot 6 · PXIe-4081
Channel 0
DC voltage
Range
Auto
Offset
--.---
000.065 mV DC
Actual range
100 mV
Input resistance
10 MOhm

InstrumentStudio™ 2018

Oscilloscopes, AWGs and FGens, DMMs, SMUs, and Power Supplies

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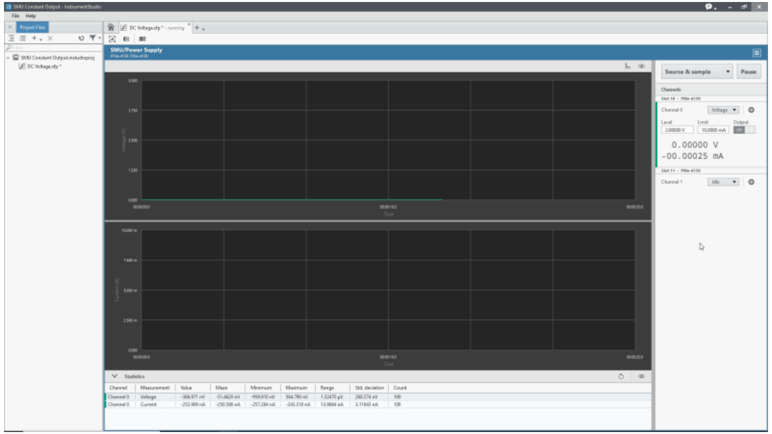
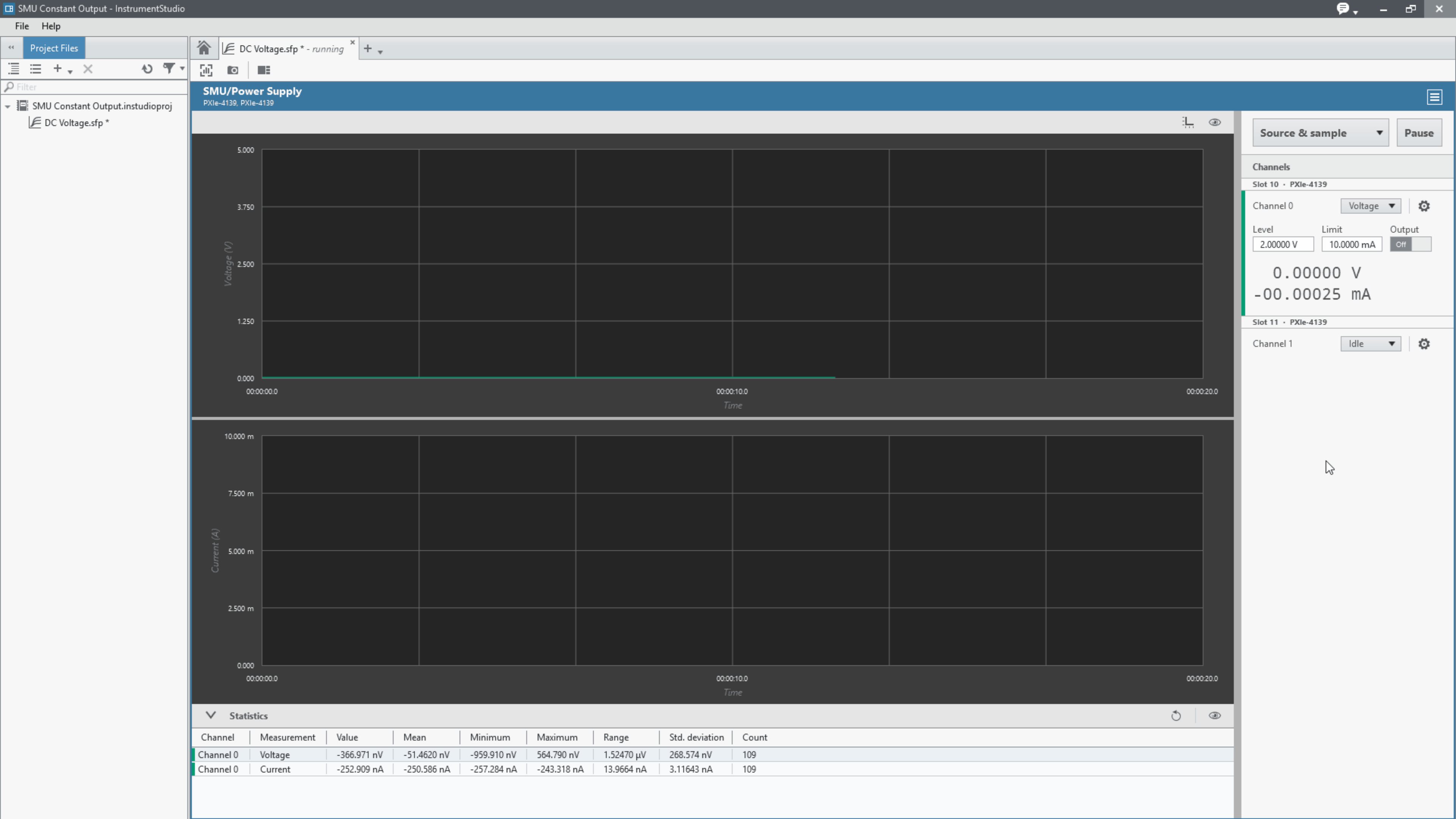
Simplified automated test system debug

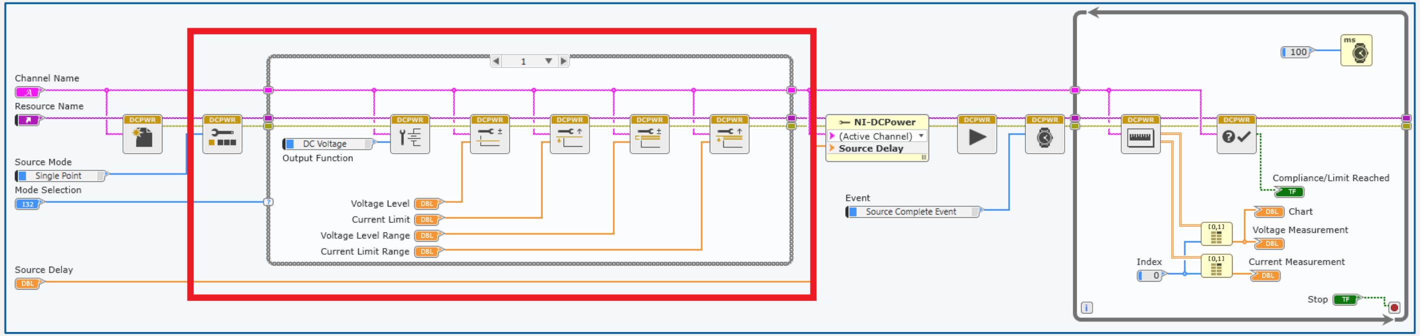
- Debug driver session—monitor and control

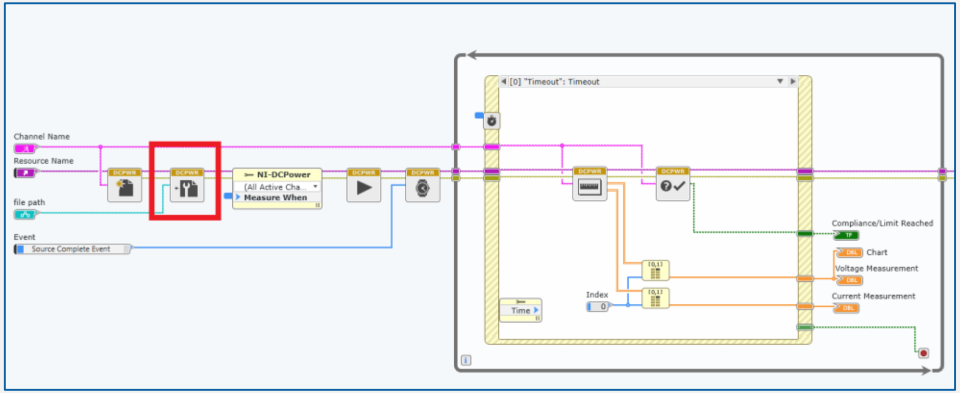


NATIONAL INSTRUMENTS


SMU Constant Output - InstrumentStudio
File
Help
Project Files
Filter
SMU Constant Output.instudioproj
DC Voltage.sfp *
DC Voltage.sfp * - running
SMU/Power Supply
PXIe-4139, PXIe-4139
5.000
3.750
2.500
1.250
0.000
Voltage (V)
00:00:00.0
00:00:10.0
00:00:20.0
Time
10.000 m
7.500 m
5.000 m
2.500 m
0.000
Current (A)
00:00:00.0
00:00:10.0
00:00:20.0
Time
Source & sample
Pause
Channels
Slot 10 · PXIe-4139
Channel 0
Voltage
Level
Limit
Output
2.00000 V
10.0000 mA
Off
0.00000 V
-00.00025 mA
Slot 11 · PXIe-4139
Channel 1
Idle
Statistics
Channel Measurement Value Mean Minimum Maximum Range Std. deviation Count
Channel 0 Voltage -366.971 nV -51.4620 nV -959.910 nV 564.790 nV 1.52470 µV 268.574 nV 109
Channel 0 Current -252.909 nA -250.586 nA -257.284 nA -243.318 nA 13.9664 nA 3.11643 nA 109

Simplifying Your Code





NI-DCPower: Source and Sample Mode

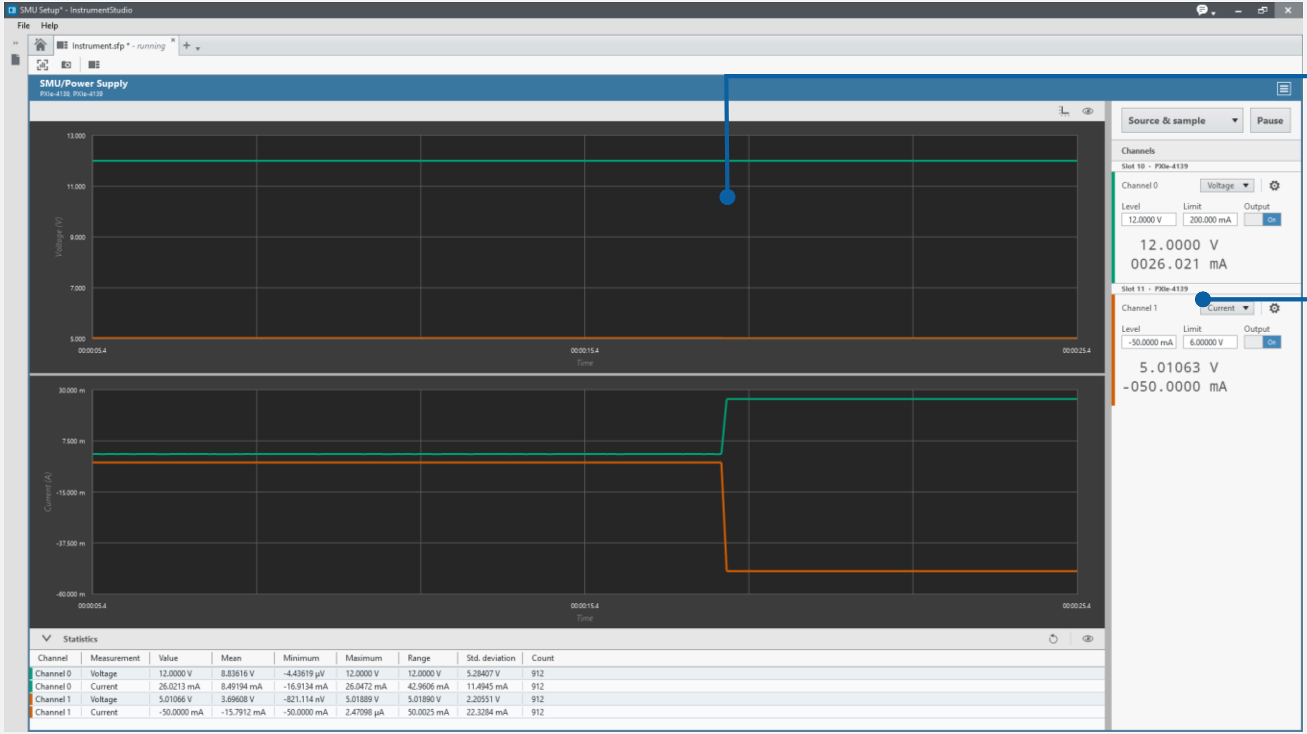
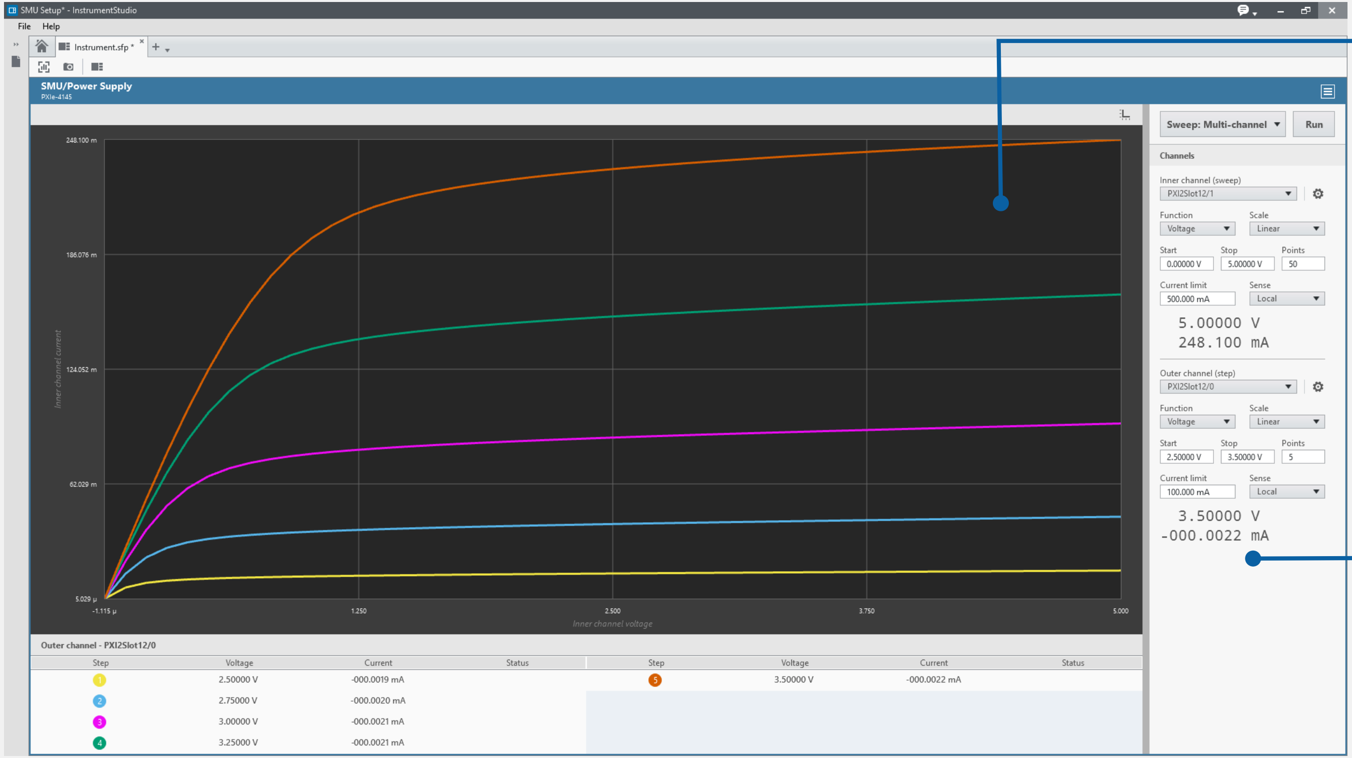


Chart voltage and current over time

Manage multiple devices in a single window

NI-DCPower: Sweep Mode



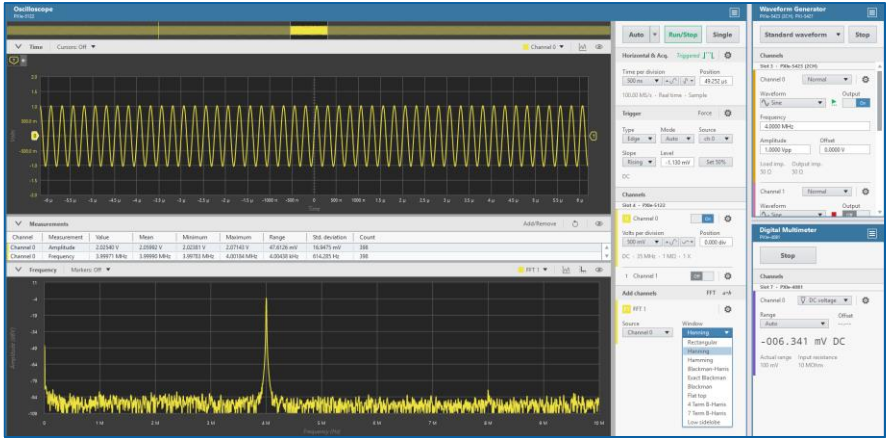
Run 1- or 2-channel sweeps

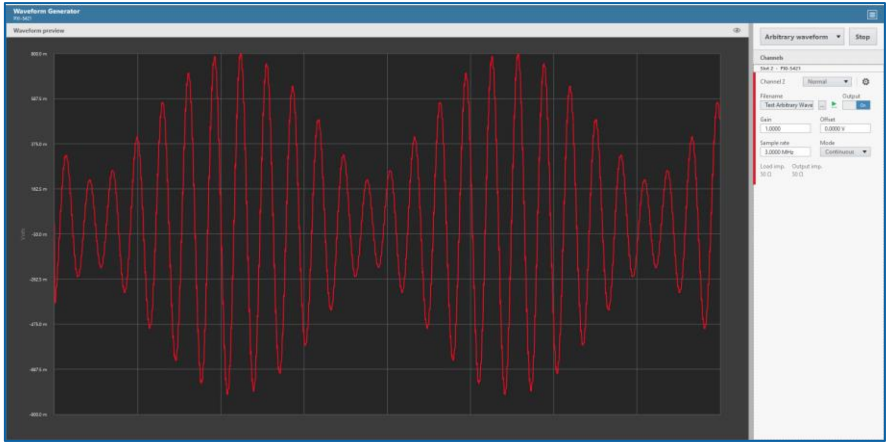
Access advanced timing and measurement settings

Recent / Planned enhancements with InstrumentStudio

InstrumentStudio™ 2018 SP2 Enhancements

- Oscilloscopes
  - Added FFT channels, frequency markers, and FFT measurements
  - Added two-channel measurements
- Waveform generators
  - Added support for arbitrary waveform generation mode
  - Added support for frequency list and sweep modes
- General
  - Added support for exporting instrument events to PXI chassis trigger lines
  - Added CSV file format for data capture

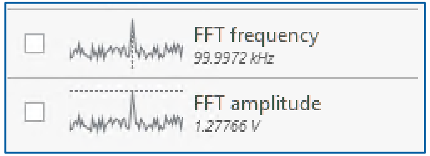


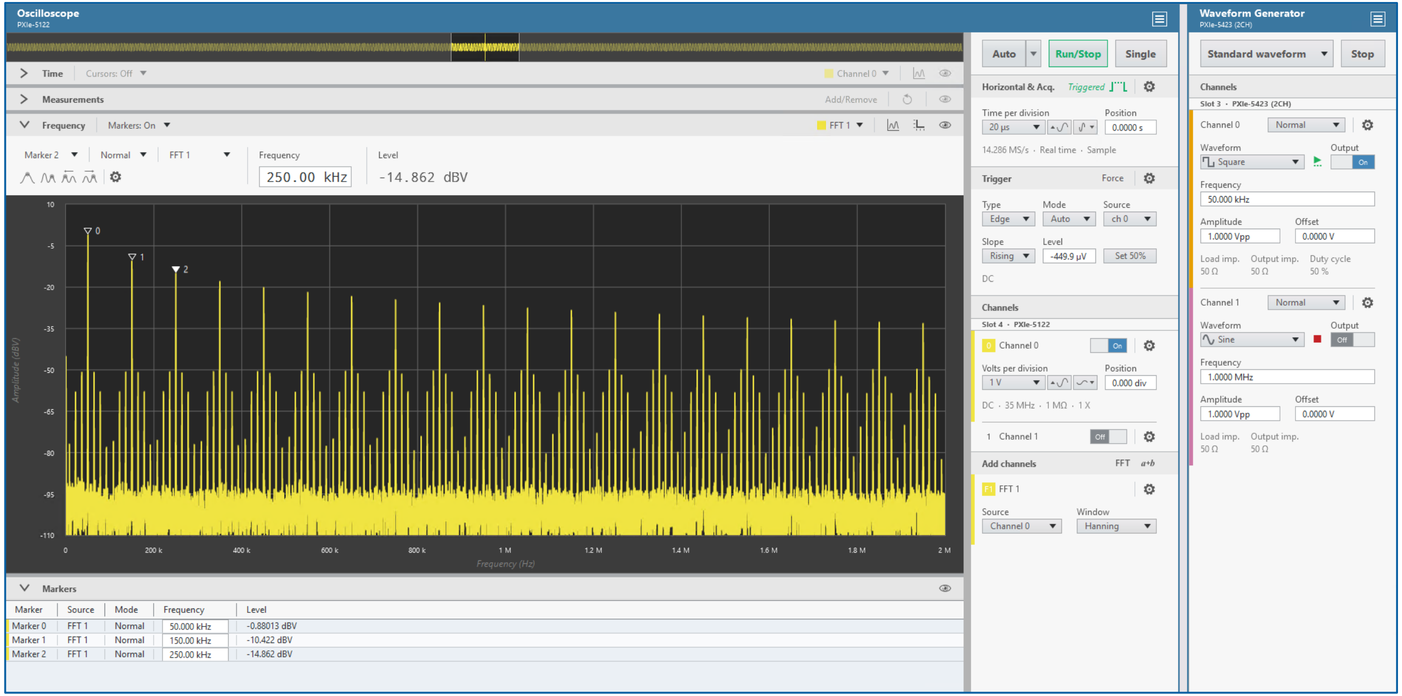


NATIONAL INSTRUMENTS™

Oscilloscope Panel: FFT Channels

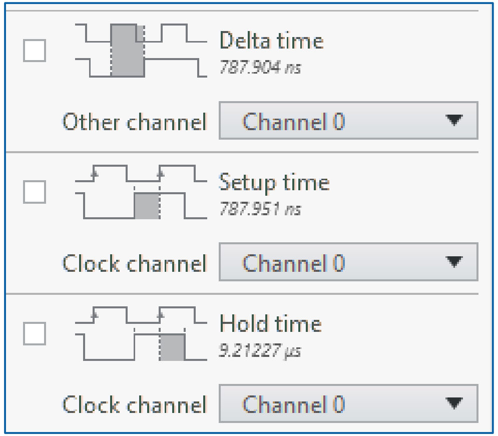
Plus frequency markers, peak search, and FFT measurements





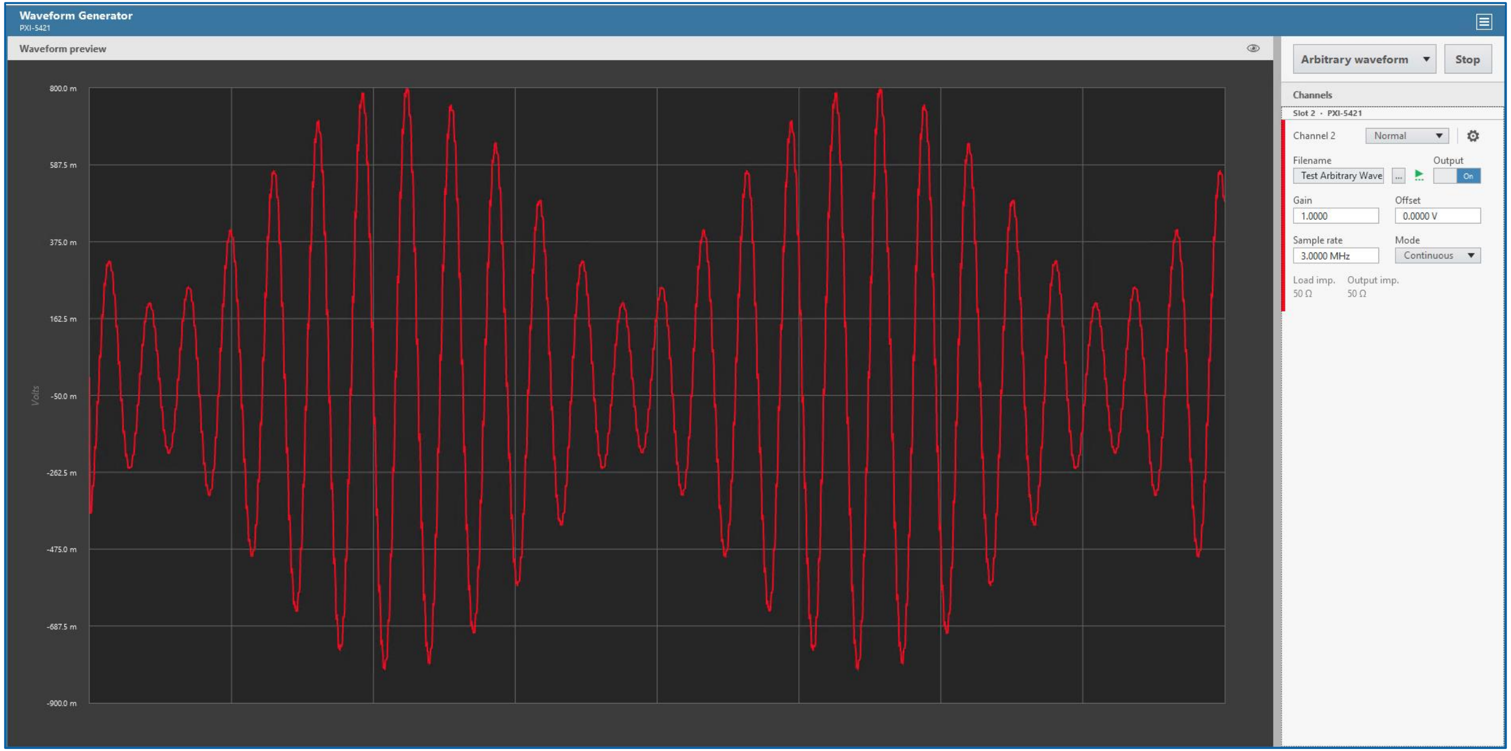
Oscilloscope Panel: Two-Channel Measurements

- Specify “other channel” to measure against primary channel
- Delta time, setup time, hold time, and crosspoint voltage



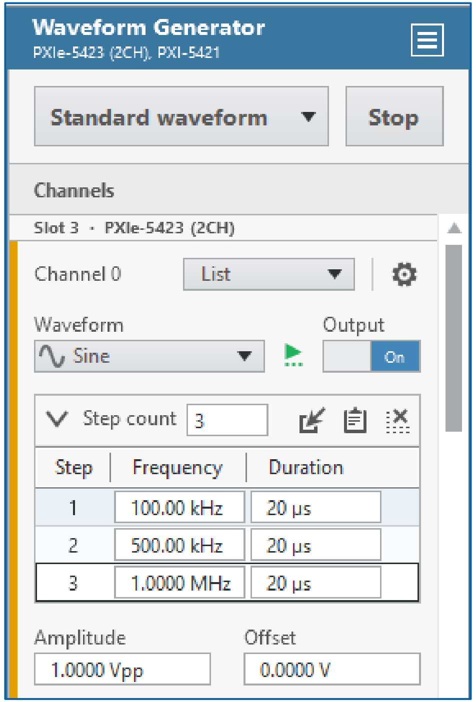
Waveform Generator Panel: Arbitrary Waveform Mode

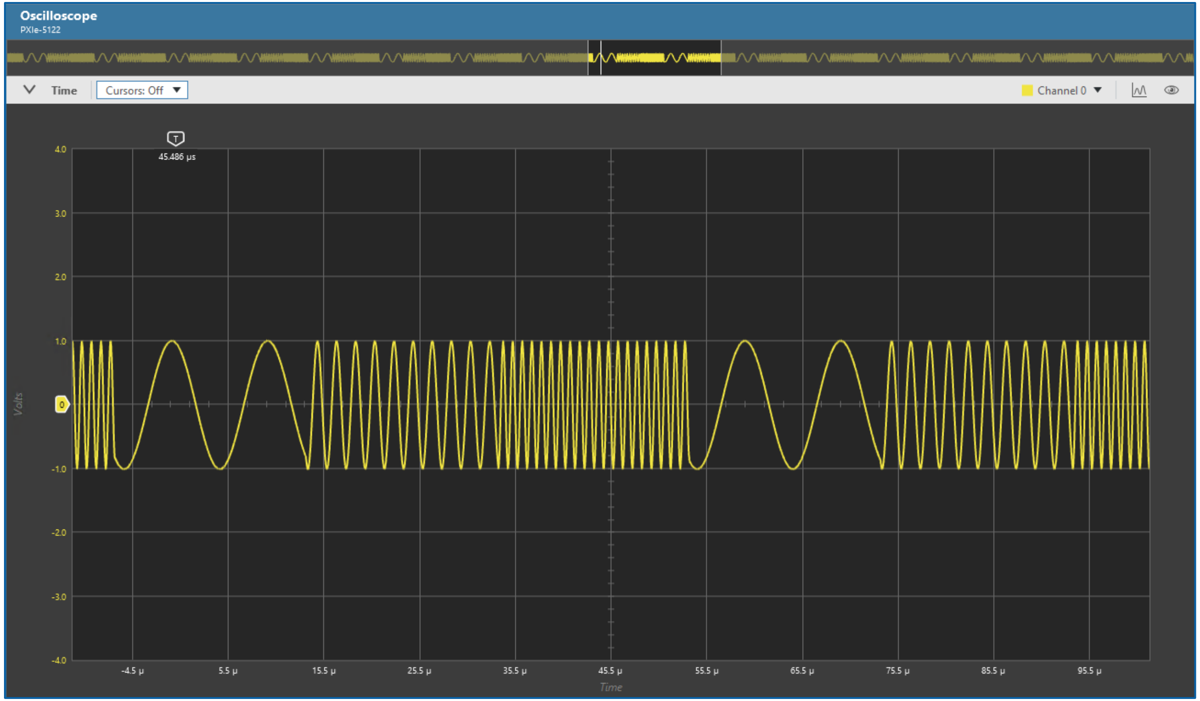
See a preview in the large panel view



Waveform Generator Panel: List Mode

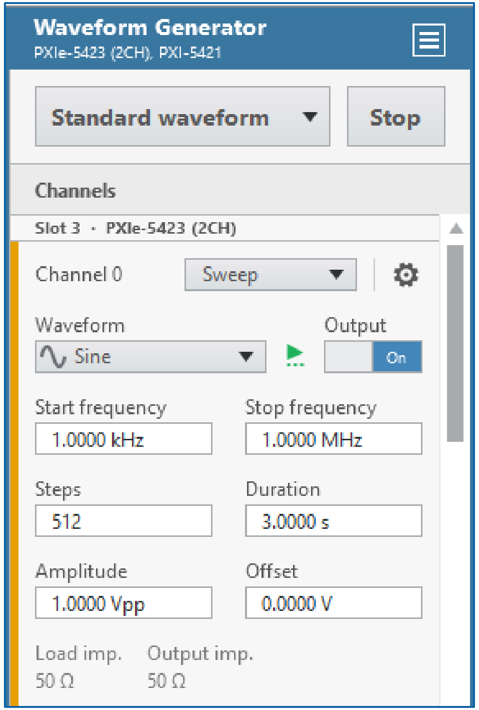
Specify a list manually or from file

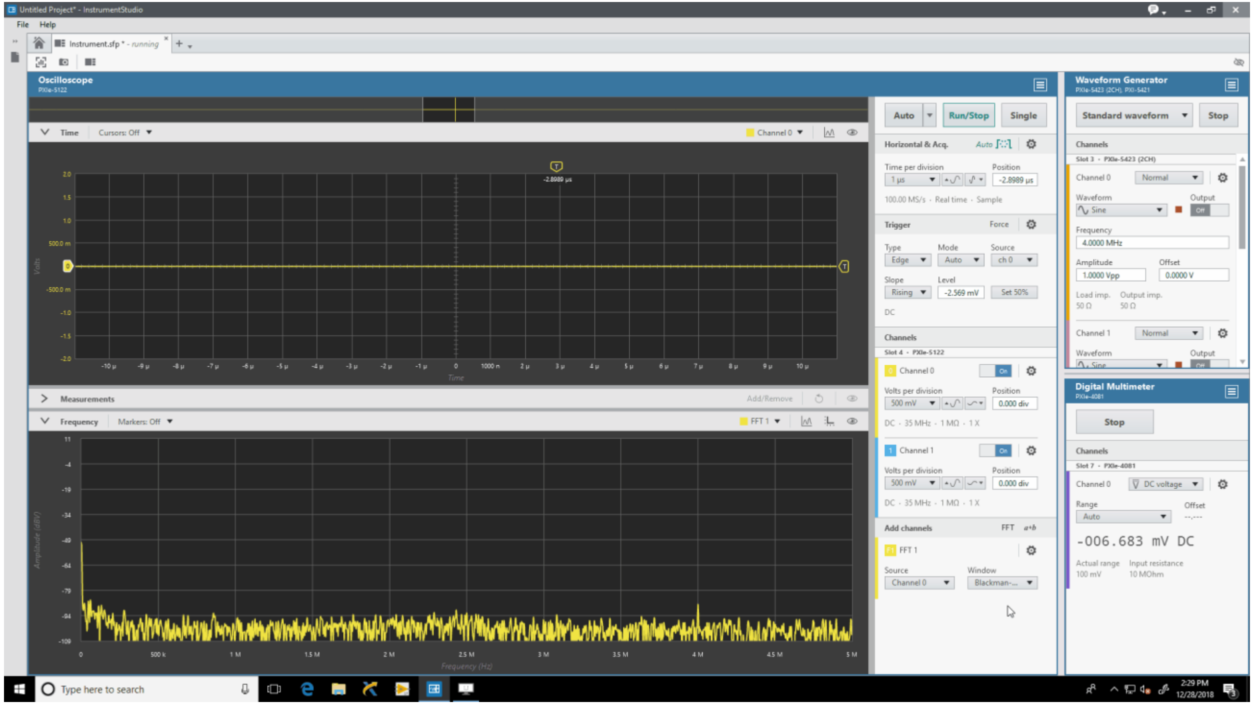




Waveform Generator Panel: Sweep Mode

Animation: FGEN Sweep + Scope FFT

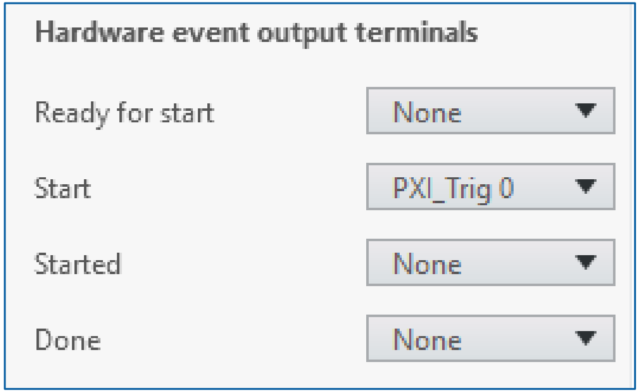


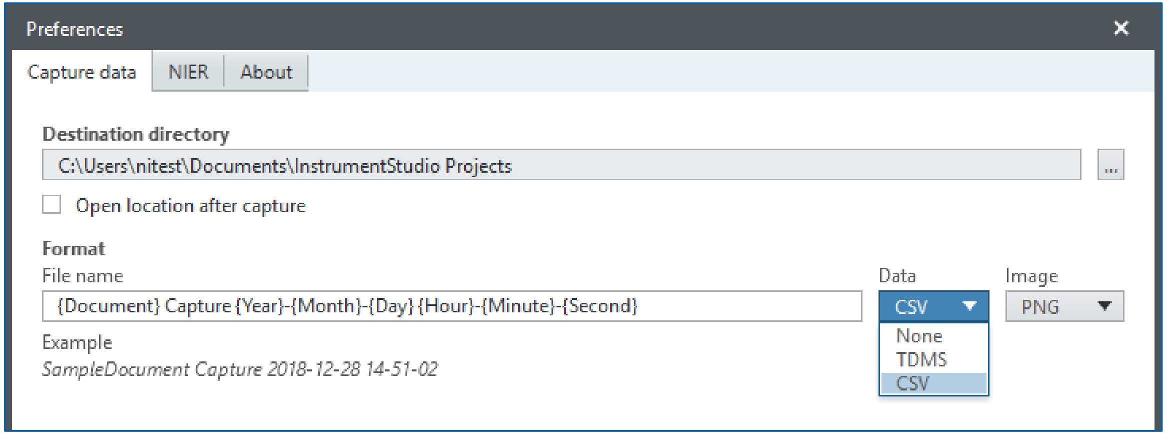


NATIONAL INSTRUMENTS

General: Instrument Event Export and CSV Data Capture

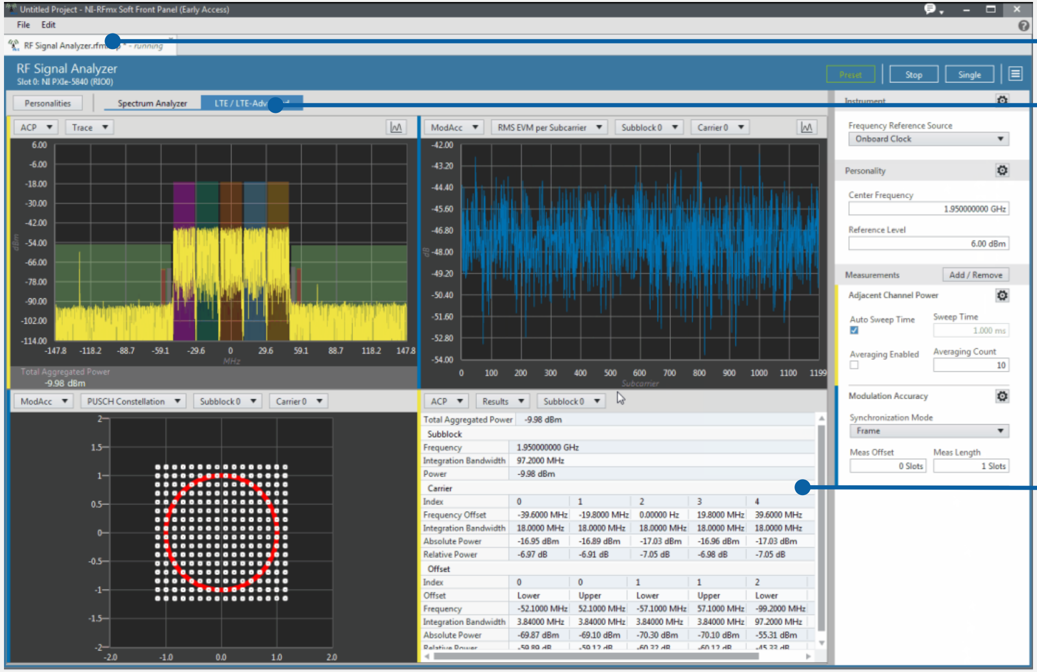
Export events to PXI chassis trigger lines. Choose between TDMS or CSV.





NI-RFmx Soft Front Panel: SpecAn and LTE/LTE-A

Similar interactive software for RF instrumentation



Multiple instances/tabs

Multiple personalities/standards

Multiple measurements and traces

NATIONAL INSTRUMENTS

FAQ

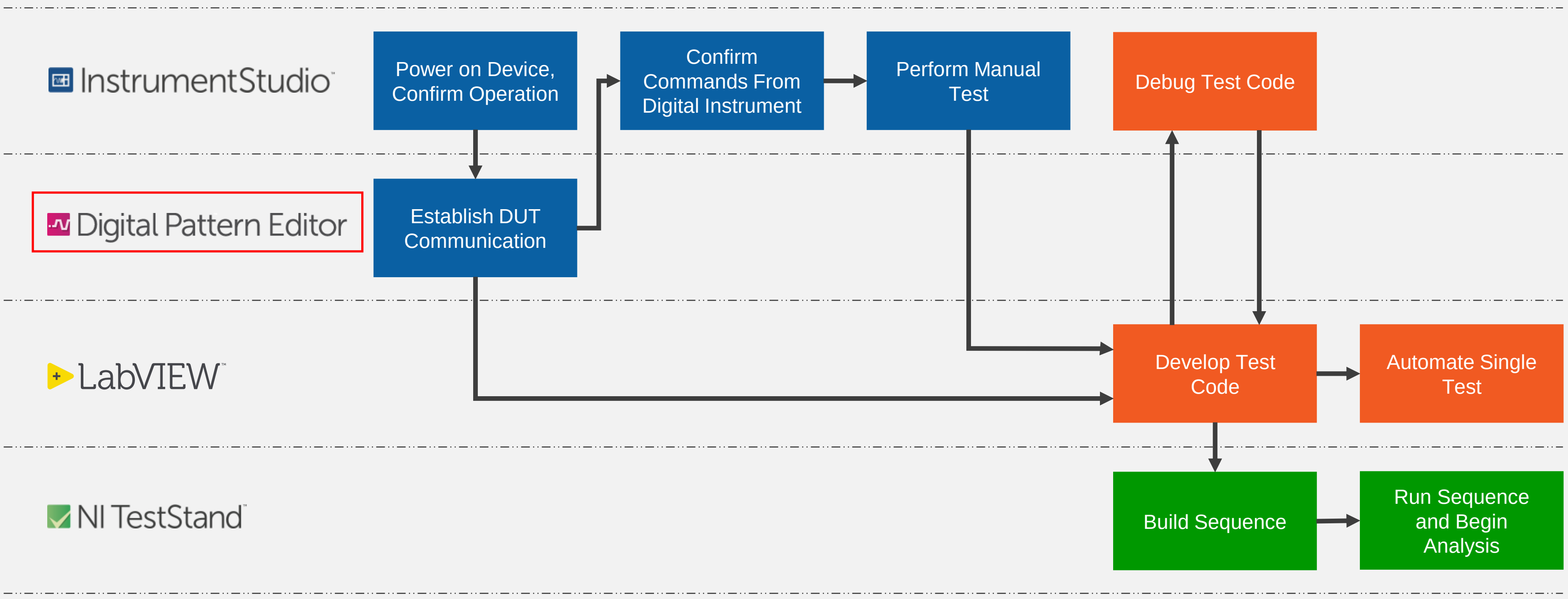
Installing InstrumentStudio

- Installs automatically with 18.1 drivers
- Or, download separately from Package Manager
  - This stand-alone version contains only the runtimes of the four drivers. You can use InstrumentStudio by itself, but you cannot perform operations that would require the API (config export to programming environments or debug monitor/control modes)

Supported hardware

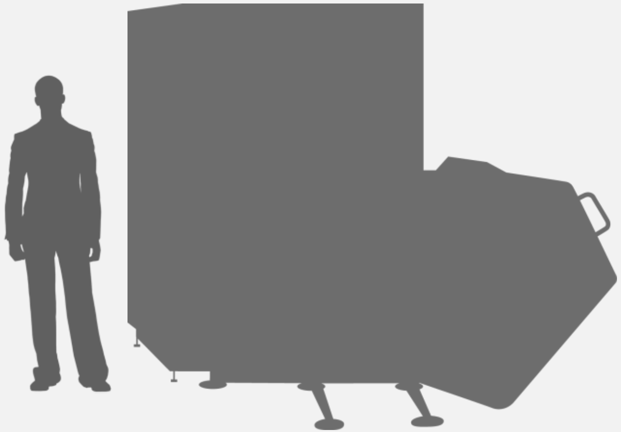
- Any hardware (PXI, PCI, USB) that is supported by NI-SCOPE, NI-FGEN, NI-DMM, or NI-DCPower 18.1 or later; full hardware list at ni.com/instrumentstudio

Demo Workflow



ATE Not Designed to Serve Validation

- Too expensive
- Custom cooling
- High-power connections
- Designated space in labs
- I/O options are fixed and aging
- Renting ATE from other groups
- Trying to partner overseas to use production ATE
- Lack of ATE availability limits test productivity



Lab Test System

ATE

Scalable ATE-Class Digital

Modular hardware

Timing and DC parametric measurements

ATE digital patterns

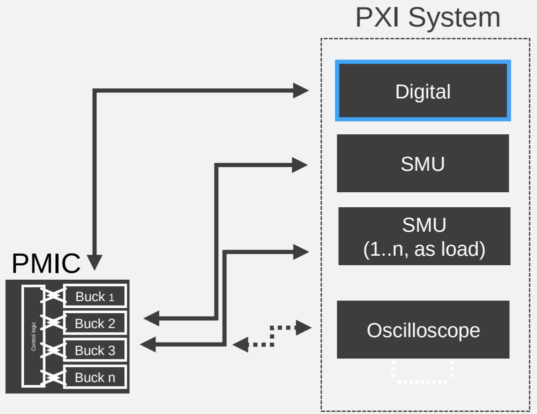
Production test speed

Digital: Consistent Terminology With ATE

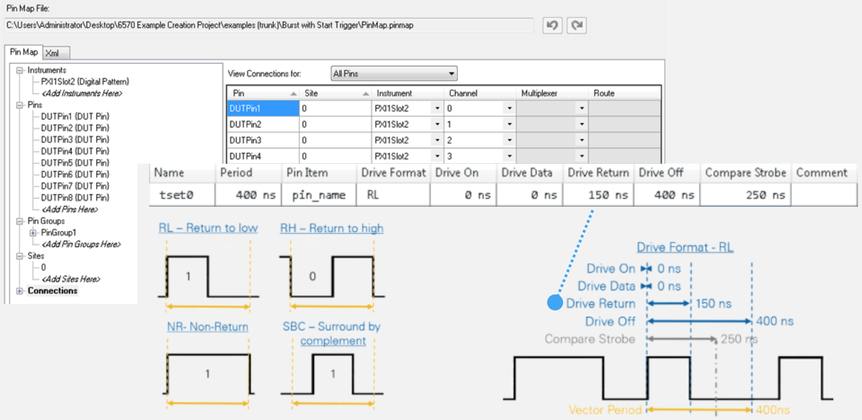
- DUT-centric programming by pin
- Time sets with cycle-to-cycle edge placement and drive formats
- Pin electronics for edge placement and IV measurements

Why it matters

- Paradigm consistency paves the way for reuse (patterns, code modules) and easier correlation with production ATEs



NI Digital Pattern Editor

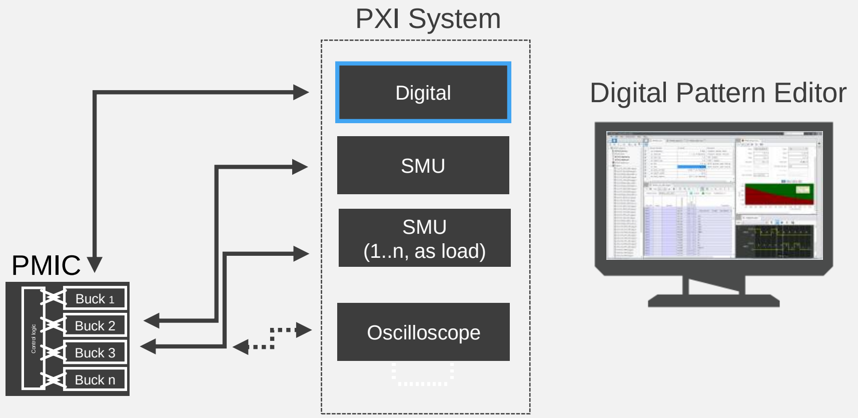


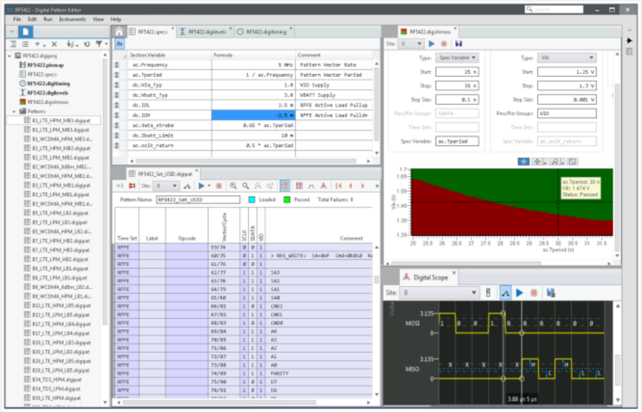
Digital: Pattern Editor Software

- Create, edit, and import digital test patterns
- Debug tools like History RAM and Digital Scope
- Shmoo plotting for margining and characterization

Why it matters

- Out-of-the-box functionality to import/create, debug, and burst patterns
- Go from configuration to test faster with out-of-the-box application software



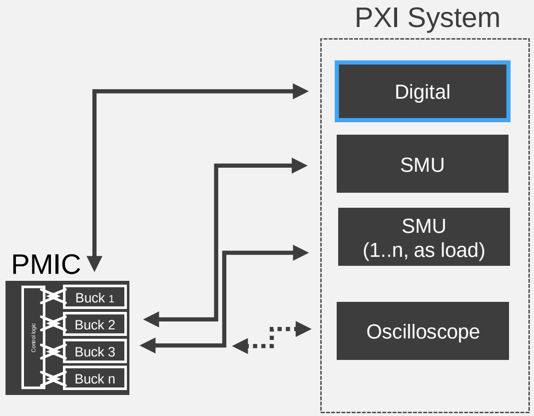


Digital: Test System Integration

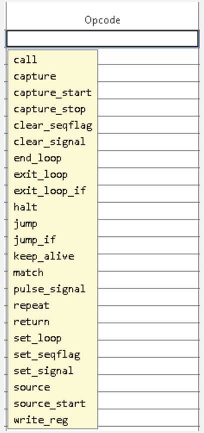
- Logical operations within patterns like looping, jumping, and matching
- Multimodule, cross-module, and cross-instrument operations

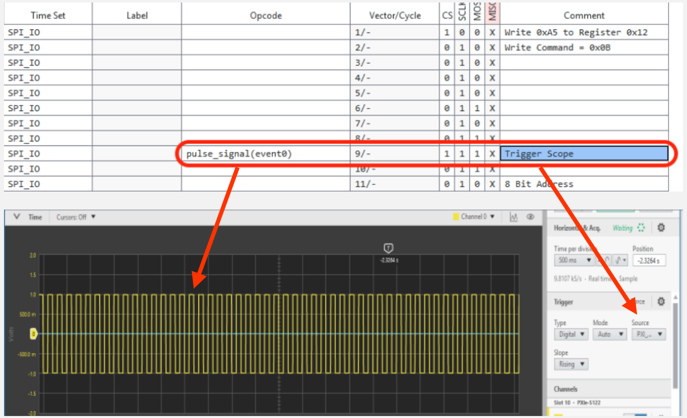
Why it matters

- Flexible execution of patterns including dynamic source and capture memory operations
- Integrated measurement capability of all instruments within a digital pattern



Digital Pattern Editor



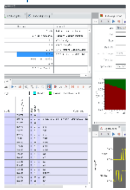


PXI Digital Pattern Instruments

PXIe-6570 and PXIe-6571

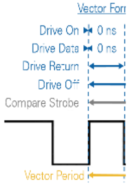
Built for Semiconductor Device Test

- RFICs and Transceivers
- Power Management ICs
- MEMS
- IoT Devices with Integrated MCUs and Sensors



ATE Development and Debug Features

- Digital Pattern Editor
- Source and Capture Memory
- History RAM, Digital Scope, Pin View, and System View
- Shmoo Plots



ATE Test Capability

- Time Sets and Edge Placement
- Opcodes
- Multi-site Support
- Integrated Per-Channel PPMU
- Up to 512 Synchronized Channels

NATIONAL INSTRUMENTS

PXI Digital Pattern Instruments: PXIe-6570 and PXIe-6571

	PXIe-6570	PXIe-6571*
Module Width	2 slots	1 slot
Active Load	24 mA	16 mA
Pin Electronics	Digital: -2 V to +6 V, 32 mA PPMU measure voltage: -2 V to +6 V, 32 mA PPMU force voltage: -2 V to +7 V, 32 mA	
Channels	32 per module	
	256 maximum in a synchronized subsystem	512 maximum in a synchronized subsystem
Maximum Vector Rate	100 MHz (10 ns minimum vector period)	
Maximum Data Rate	200 Mb/s	
Maximum Clock Rate	160 MHz**	
Pattern Timing	31 time sets 39.0625 ps edge placement resolution	
Drive Formats	Non-return (NR), return to low (RL), return to high (RH) (100 MHz max), surround by complement (SBC) (50 MHz max)	
Vector Memory Depth	128 M/channel	
Opcode Support	Flow control, sequencer flags and registers, signal, source and capture, subroutine	
Source and Capture Engines	Broadcast or site-unique Serial or parallel 8 per instrument	
SCAN Support	Flattened SCAN patterns, up to 128 M	

* Note that the PXIe-6571 requires a chassis with 82 W slot cooling capacity, such as the PXIe-1095. In STS, this requires the high-density test head revision.

** Clock rates >133 MHz will have a non-50% duty cycle.

A Modular Approach to Digital Test

Synchronized PXI Instruments

- Subnanosecond synchronization with other PXI modules
- Full suite of instruments from DC to mmWave

PXIe-8880 Controller

- Intel Xeon 8-core processor (2.3 GHz)
- 24 GB/s system bandwidth
- Up to 24 GB DDR4 1866 MHz RAM
- Gen 3 PCI Express technology

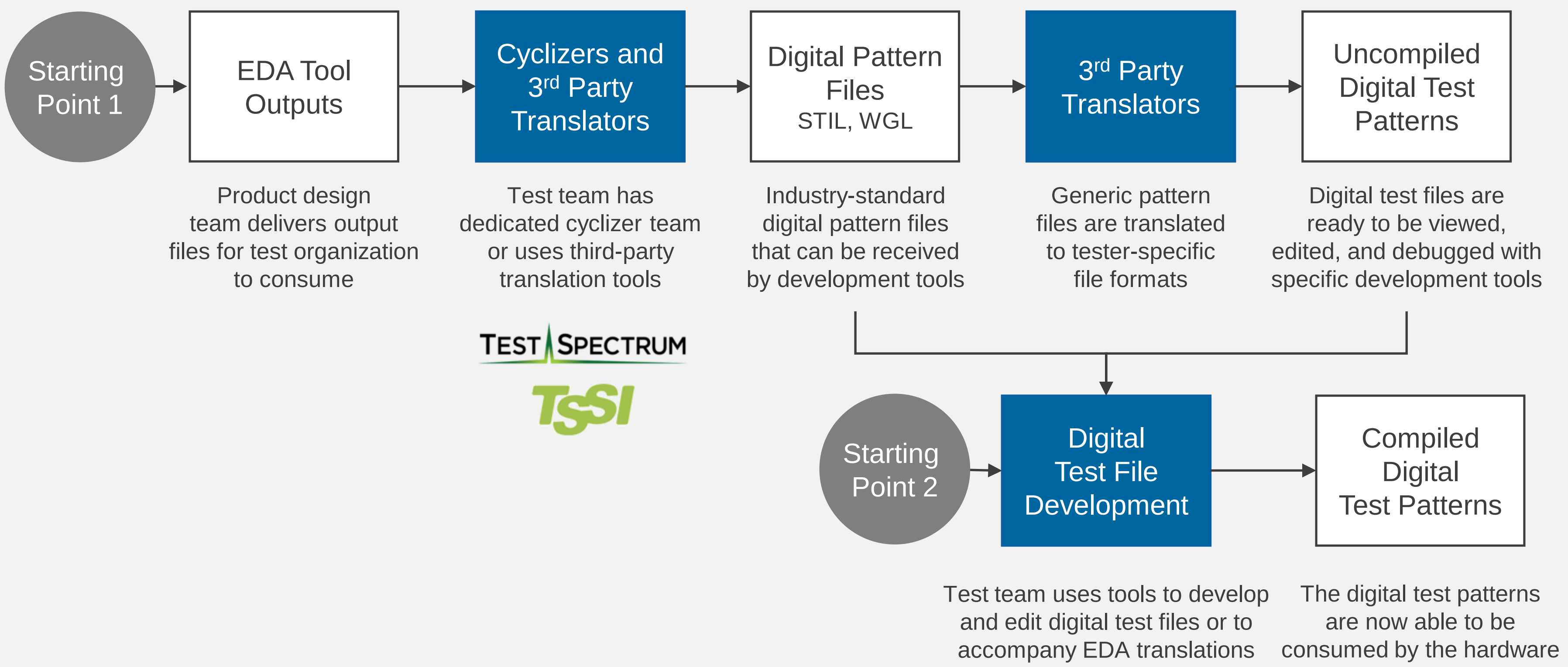
PXIe-6571 Digital Pattern Instrument

- 32 channels per module
- Up to 512 synchronized channels in digital subsystem
- 31 time sets
- 100 MHz vector rate
- 128 M vector memory

PXIe-1095 Chassis

- 18 PXI Express slots
- Up to 24 GB/s system bandwidth
- 82 W slot cooling capacity
- Peer-to-peer data streaming
- Gen 3 PCI Express technology

Semiconductor Digital Pattern Workflow



NATIONAL INSTRUMENTS

Test Engineer Workflow With NI

Device Validation or Characterization	Automated Validation or Characterization	Multisite Validation and Production
NI Digital Pattern Editor	**LabVIEW, C, or .NET APIs**	**NI TestStand Semiconductor Module™**
Specifications and Pin Map Pin Levels and Timing Pattern Development Pattern Debug	Shmoo (Digital Pattern Editor) Test Automation	Integration Into Test Program

NATIONAL INSTRUMENTS™

Goals of Validation Test

Take Accurate Measurements

Develop Understanding of DUT Performance

Shorter Test Time With Less Effort

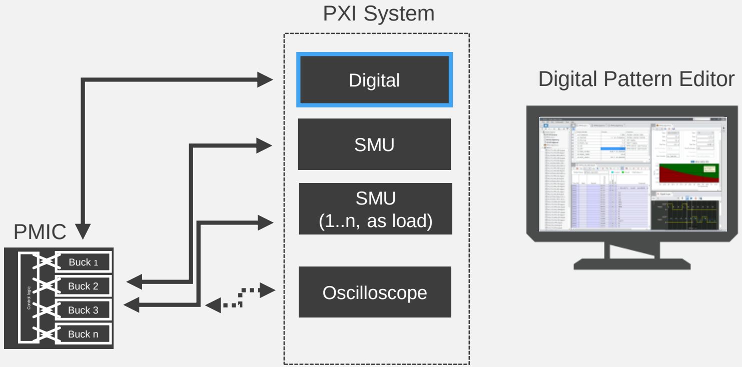
Characterization, Validation, Evaluation

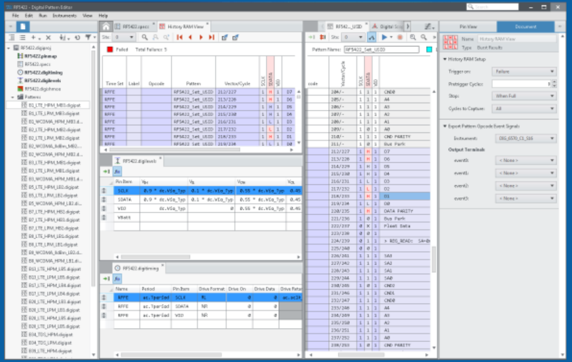
Required Tools and Tasks

Shmoo Plots for Margining

Multiple-Instrument Automation

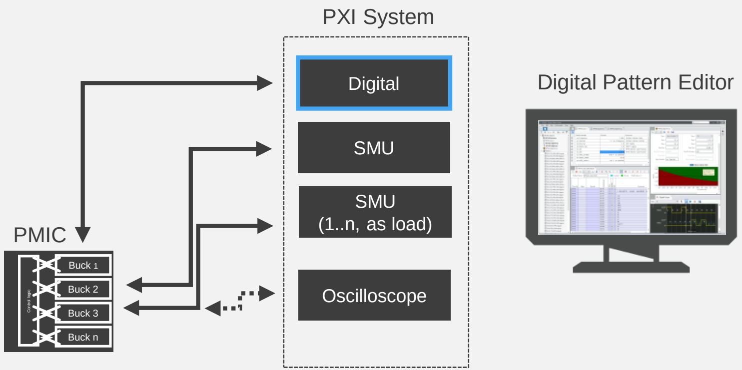
NATIONAL INSTRUMENTS™

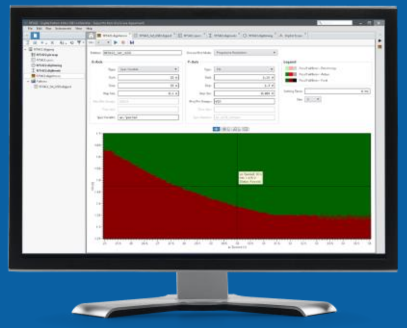




DEMO: Create and Edit Digital Patterns

- Develop digital patterns with the Digital Pattern Editor
- Create pin and channel maps
- Set specifications, timing, and levels
- Standard ASCII format for pattern files

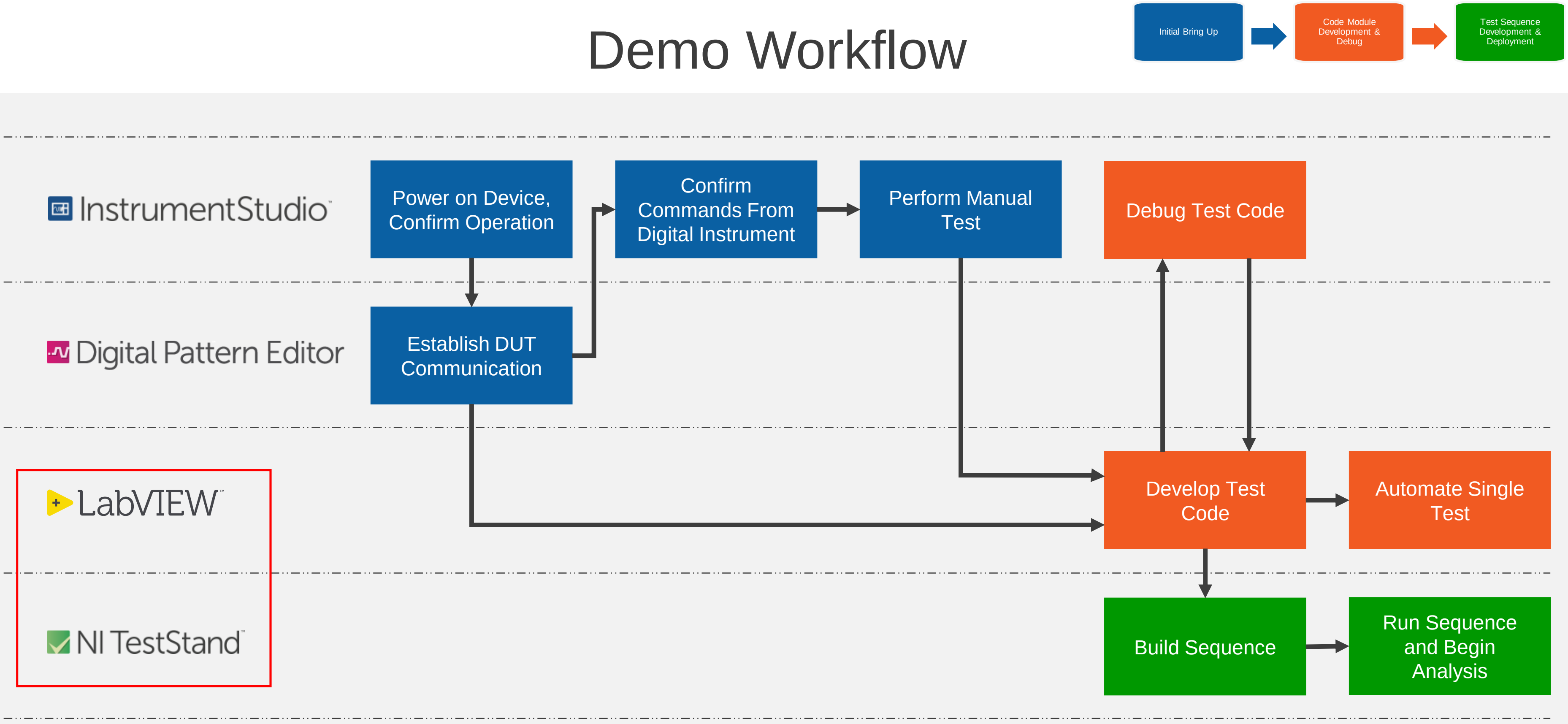




DEMO: Debug Digital Patterns and Create Shmoo Plots

- History RAM overlay and viewer
- Pin and system views
- Digital scope
- Shmoo plot

Demo Workflow

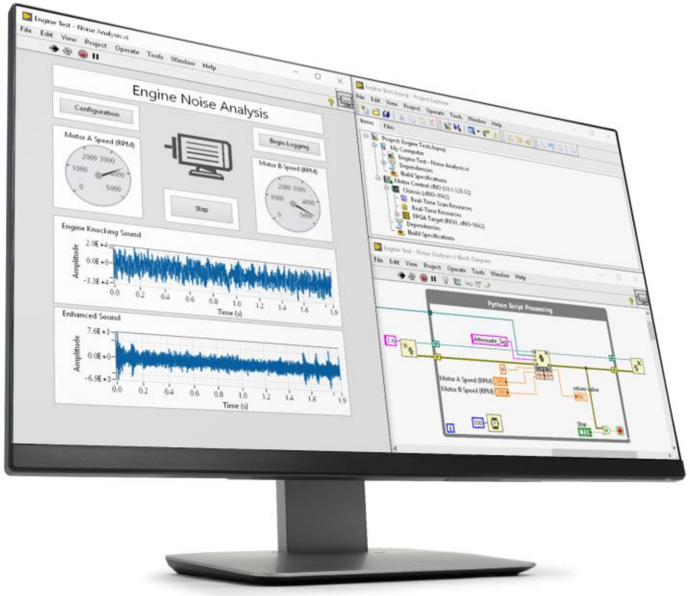


NATIONAL INSTRUMENTS

LabVIEW 2018

FEATURES AT A GLANCE

- Automate software building and execution with the LabVIEW Command Line Interface
- Natively call Python scripts with the Python Node
- Prototype FPGA code faster with improved floating-point operations, new compile tools, and LabVIEW FPGA 64-bit



LabVIEW 2018 simplifies the design of distributed test, measurement, and control systems to decrease your time to market.

NATIONAL INSTRUMENTS

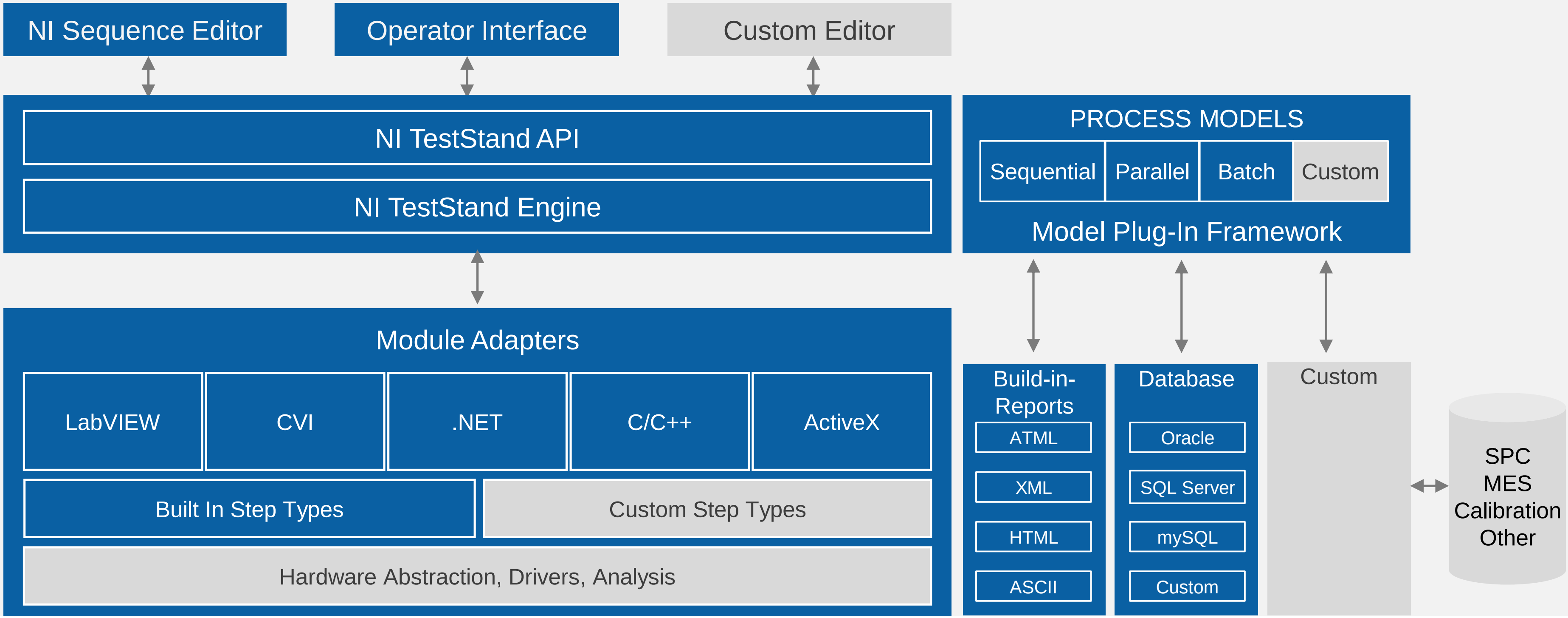
TestStand

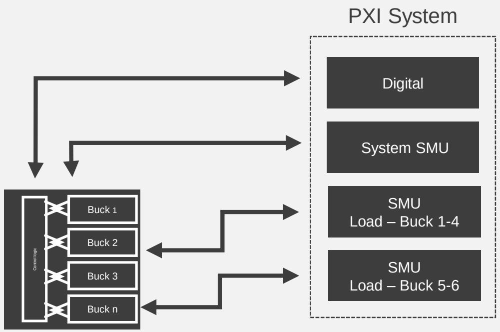
Industry-Standard Test
Management Software

FEATURES AT A GLANCE

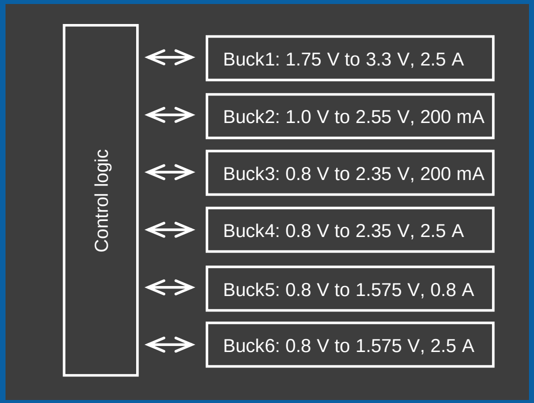
- Author, execute, and debug test sequences
- Leverage test code developed in any language
- Test many devices in parallel
- Generate reports
- Integrate with databases
- Extend the software to meet custom requirements
- Develop professional operator interfaces

TestStand Architecture





InstrumentStudio LabVIEW Digital Pattern Editor NI TestStand



DEMO: Develop a Sample Automated Test Sequence for Power Efficiency and Load Regulation

- Use InstrumentStudio to confirm DUT functionality and debug
- Use Digital Pattern Editor to develop patterns to communicate with DUT
- Automate tests with LabVIEW
- Sequence numerous tests and generate reports with TestStand

Agenda

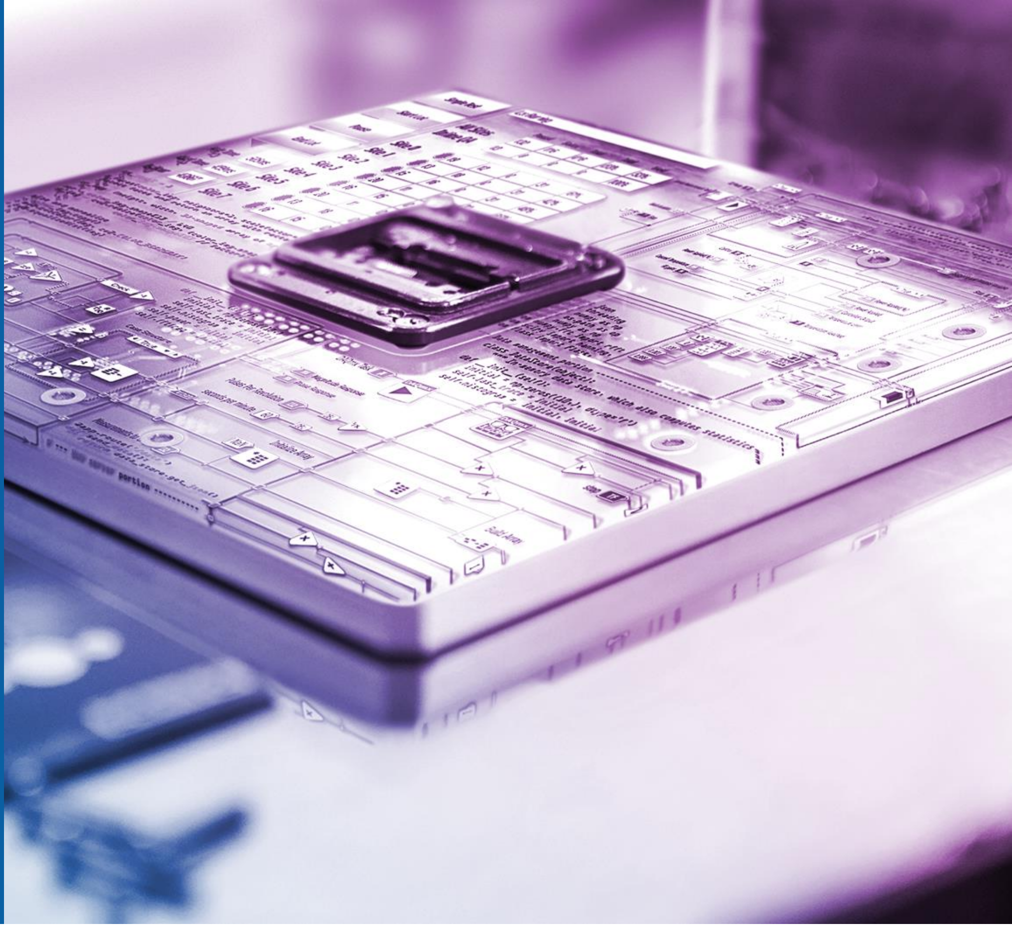
Time	Topic	Presenter	Demo
9:00	**Welcome and Introductions**		
9:15	**Lower the Cost of Test While Improving Time to Market with Better Cross-Functional Workflows**	Joshua Young	No
10:00	**Introduction to the PXI Platform**	Tarek Safwan	No
10:30	**Using a Modular Platform for Mixed-Signal Semiconductor Characterization** • Use InstrumentStudio™ to save project configurations, export measurement results, monitor instruments and perform interactive debugging • See how the digital capability of semiconductor ATE systems can be replicated with a lab-friendly footprint • Live demonstration of DUT characterization using modular instruments	Tarek Safwan	Yes
12:00	**Lunch/Networking**		
13:00	**Using a Modular Platform for RFIC Semiconductor Characterization**	Mher Minasyan	Yes
13:30	**RF Measurement Optimization with RFmx**	Mher Minasyan	Yes
14:15	**Beyond Bluetooth 5**	Mher Minasyan	Yes
14:45	Wrap-up and summary	All	

NATIONAL INSTRUMENTS

Using a Modular Platform for RFIC Semiconductor Characterization

Smarter Test From Characterization to Production

Mher Minasyan
Applications Engineer
National Instruments



Key Innovations for RFIC Semiconductor Test

NI Vector Signal Transceiver (VST)

- FPGA-based servoing for measurement acceleration
- Up to 1 GHz instantaneous bandwidth for wide range of wireless technologies
- R&D-grade measurement performance with up to -50 dB EVM for 802.11ax

NI Source Measure Units (SMUs)

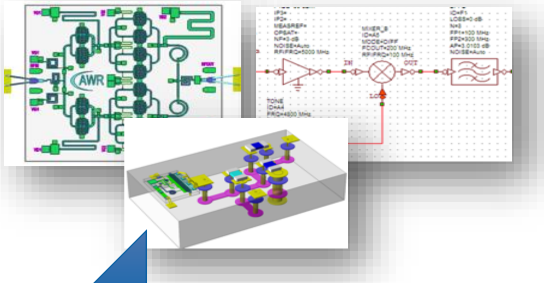
- Broad IV range: 200 V (20 W), 3 A (10 A pulse)
- Current resolution to 10 fA
- Max sampling to 1.8 MS/s
- NI SourceAdapt technology for fast settling in presence of capacitive loads
- Best-in-class channel density

NI Digital Pattern Instrument

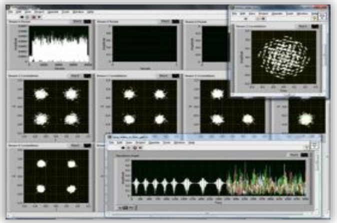
- ATE-class digital (with PPMU) in PXI
- Out-of-the-box Digital Pattern Editor software
- Time sets, drive formats, opcodes, source and capture, history RAM, Shmoo

NI Provides Tools from RF Design to Automated Test

AWR Circuit to System Design and Simulation



Communications System Design

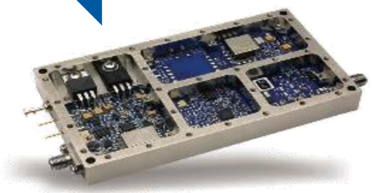


Test & Measurement

Design

Research & Prototyping

Automated Test



Components & Assemblies

Software Defined Radio

RF & Wireless Test

NATIONAL INSTRUMENTS

High-Performance PXI* RF Instruments

PXIe-5840 Vector Signal Transceiver	
Frequency Range	9 kHz to 6 GHz
Maximum Bandwidth	1 GHz
Maximum Output Power	+20 dBm
802.11ax EVM	-50 dB (with external LO)

PXIe-5668R Vector Signal Analyzer	
Frequency Range	20 Hz to 26.5 GHz
Maximum Bandwidth	765 MHz
Phase Noise	-129 dBc/Hz (1 GHz, 10 kHz offset)
RMS Noise Floor (without pre-amp)	<-155 dBm/Hz (1 GHz) <-148 dBm/Hz (26 GHz)

NATIONAL INSTRUMENTS

***(PCI Extension for Instrumentation)**

RF Instrumentation – Frequency Coverage

Vector Signal Transceivers up to 6.5 GHz

High Frequency Instruments up to 26 GHz

Mechanical and Solid State Relays up to 40 GHz

VNAs up to 8.5 GHz

Power Meters up to 18 GHz

NI VST Revolutionizes RF Design and Test

Only 2 PXI Slots!!

6.5 GHz VSG with 1 GHz Instantaneous BW

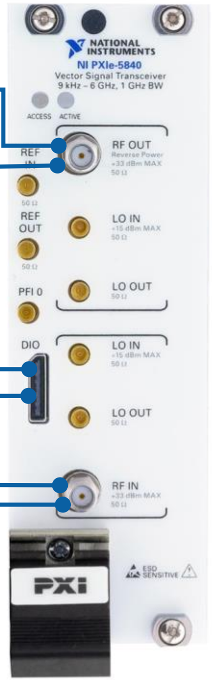
10dB Higher Output Power

60 MHz, 8 port high-speed parallel digital interface

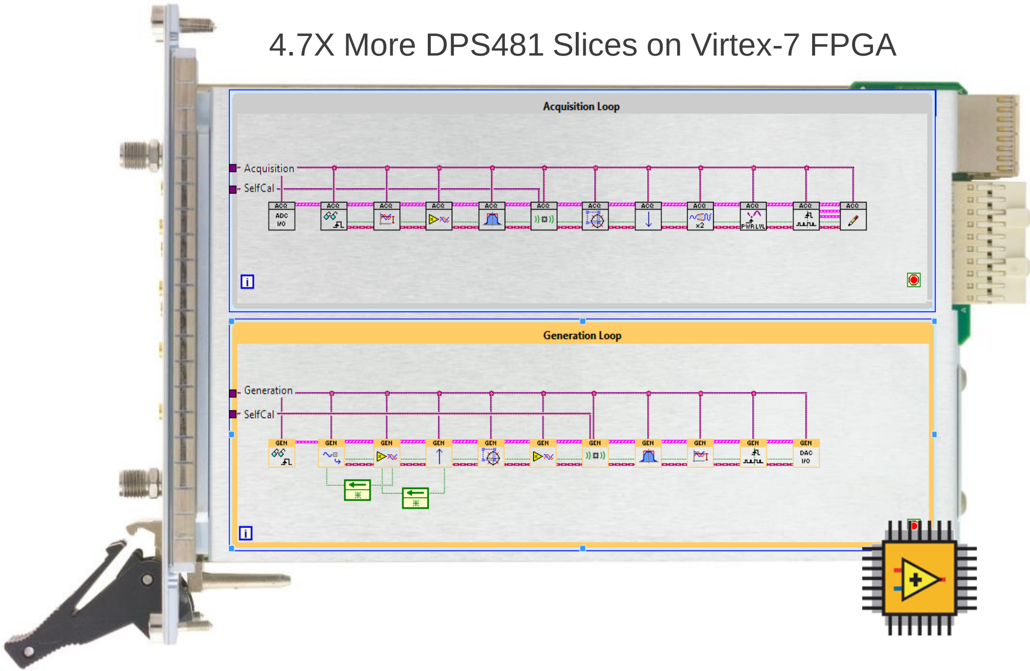
NEW high speed serial interface *(12 Gbps, 4 Tx & 4 Rx Lanes)*

6.5 GHz VSA with 1 GHz Instantaneous BW

Better EVM Performance



4.7X More DPS481 Slices on Virtex-7 FPGA



NATIONAL INSTRUMENTS

Bandwidth and Sample Rate

LTE-Advanced CA

100 MHz

WLAN

160 MHz

LTE-Advanced Pro LAA

640 MHz (theoretical)

2nd Generation VST

1 GHz Instantaneous Bandwidth

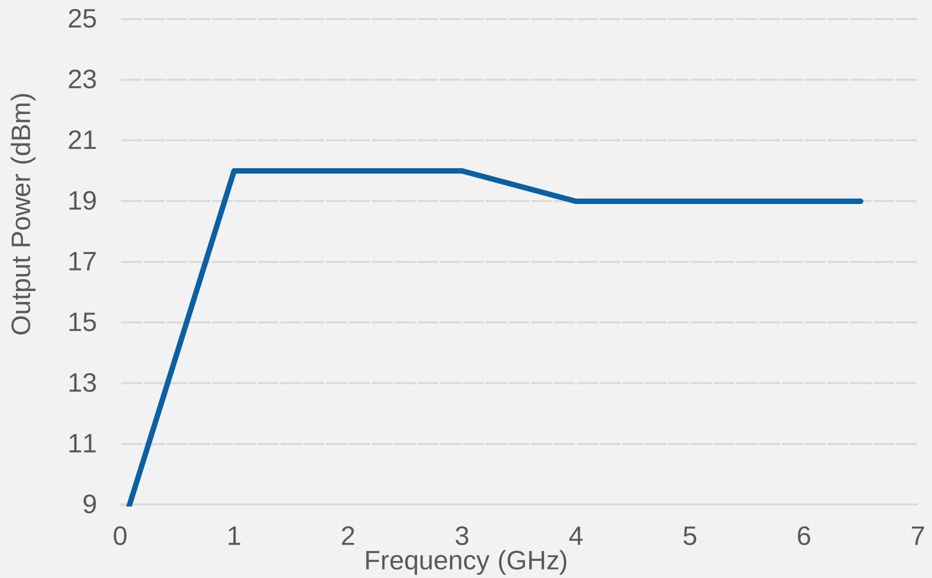
New Radio

100 MHz

New Radio CA

400 MHz

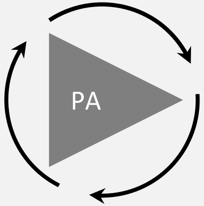
Higher Output Power with Real-Time Control



*Preliminary specifications (9/28/16)

BENEFITS

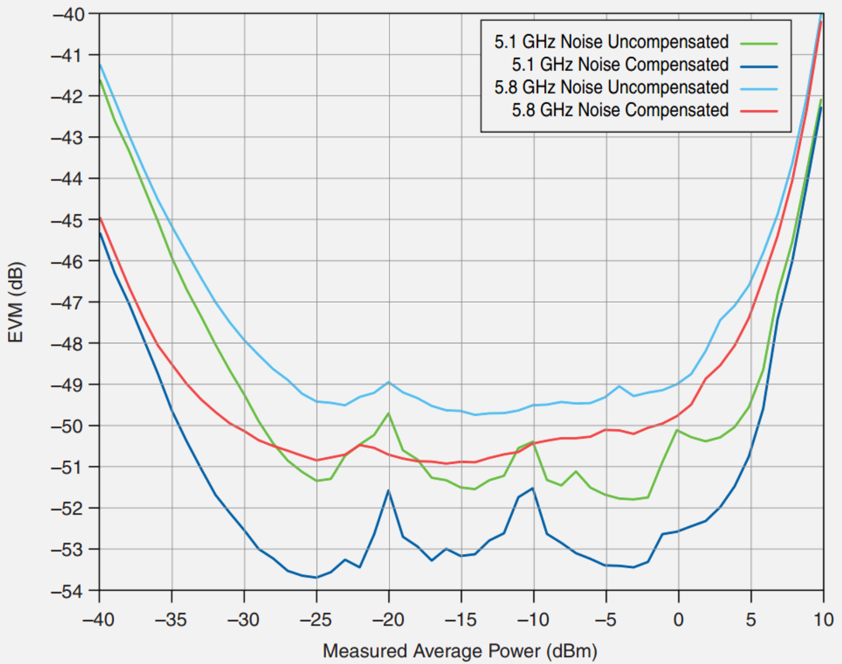
- Mitigate Loss Through Fixturing
- Test DUTs at Higher Power Levels
- Remove the Need for Driver Amps
- Better Linearity at High Output Powers
- Higher Power RADAR Signals



Control output power in real-time using LabVIEW-programmable FPGA

Excellent EVM Measurement Performance

802.11ax 80 MHz EVM Performance (Loopback), MCS11 – 1024-QAM



**External LO*

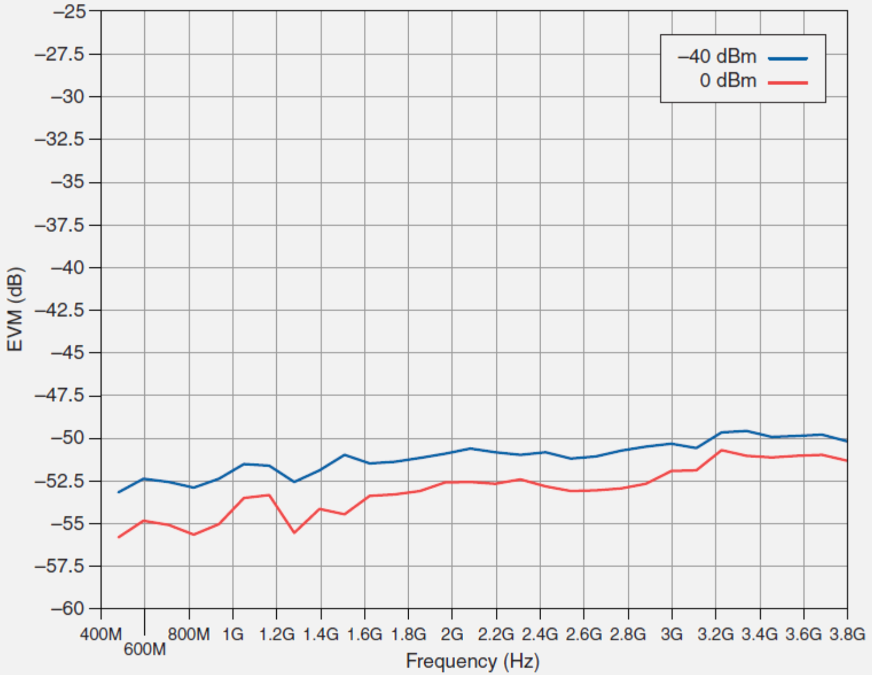
ENABLING TECHNOLOGIES

- Patented Wideband Equalization
- Optimized Dynamic Range
- Excellent Phase Noise
- Sophisticated Self-calibration Algorithms

LabVIEW Example for 802.11ax

LTE Measurement Performance

LTE EVM Performance (Loopback), 10MHz, 64-QAM

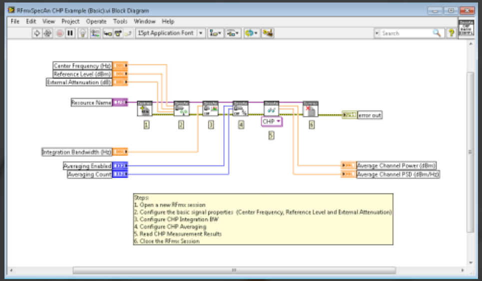
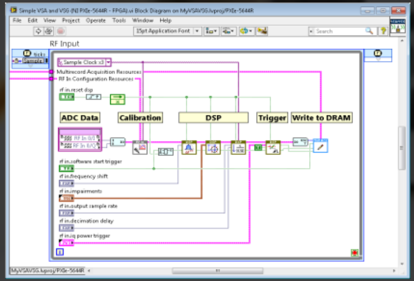


BENEFITS

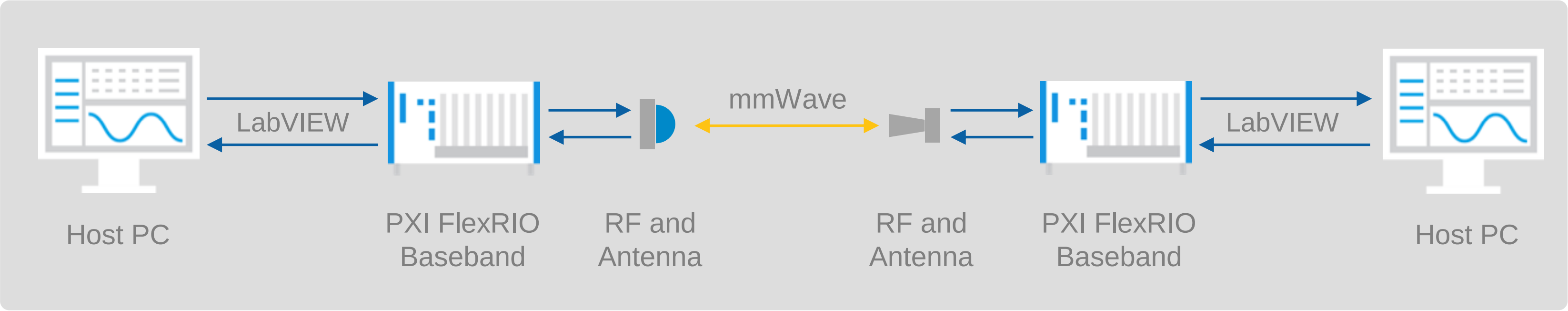
- Reliable wideband measurements
- Test envelope tracking and digital predistortion algorithms and systems

LabVIEW Front Panel for LTE

Same Powerful Software Experience

INTERACT	AUTOMATE	CUSTOMIZE
		
Soft Front Panel	RFmx	LabVIEW FPGA

Platform-based Design Approach for 5G mmWave



"It took about 1 calendar year, less than half the time it would have taken with other tools"

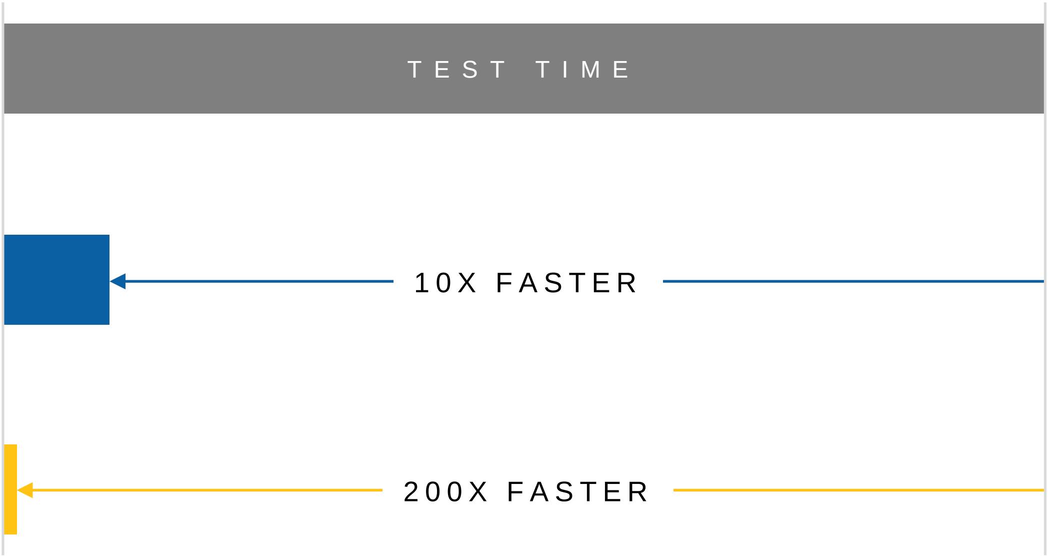
Dr. Amitava Ghosh
Head of Broadband Wireless Innovation
Nokia Networks

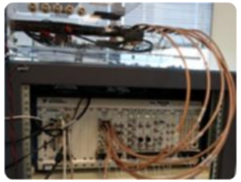
Qualcomm Reduces Test Times

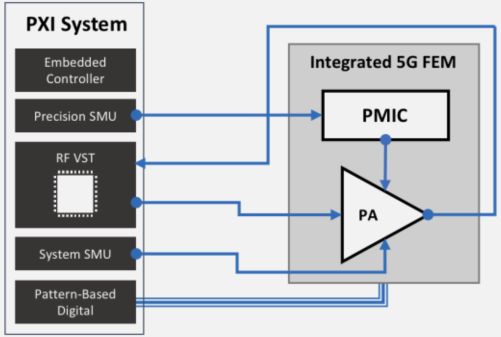
TRADITIONAL RACK AND STACK
Testing 802.11 a/b/g

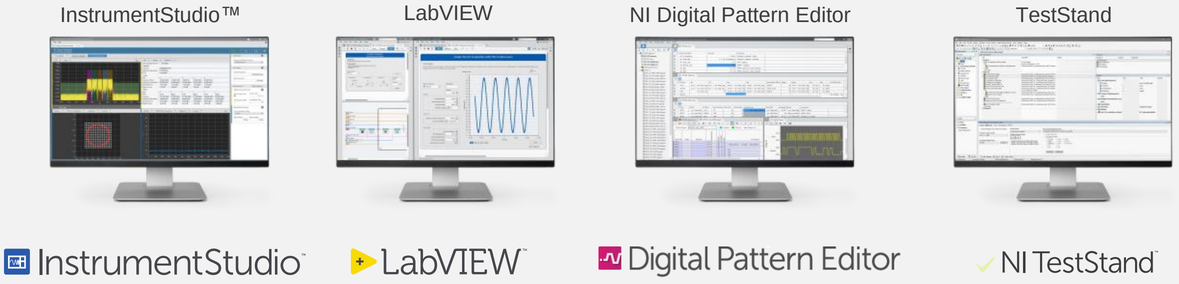
NI PXI RF AND LABVIEW
Testing 802.11 a/b/g and n

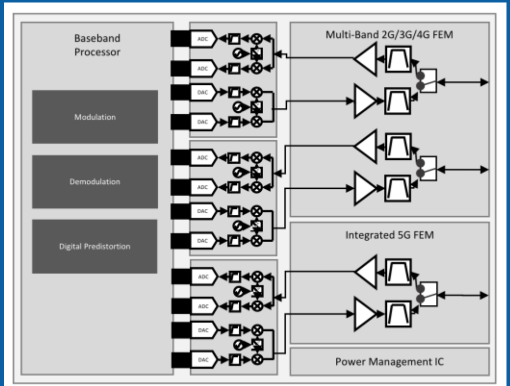
NI VST, LABVIEW, AND FPGA
Testing 802.11 a/b/g, n, and ac











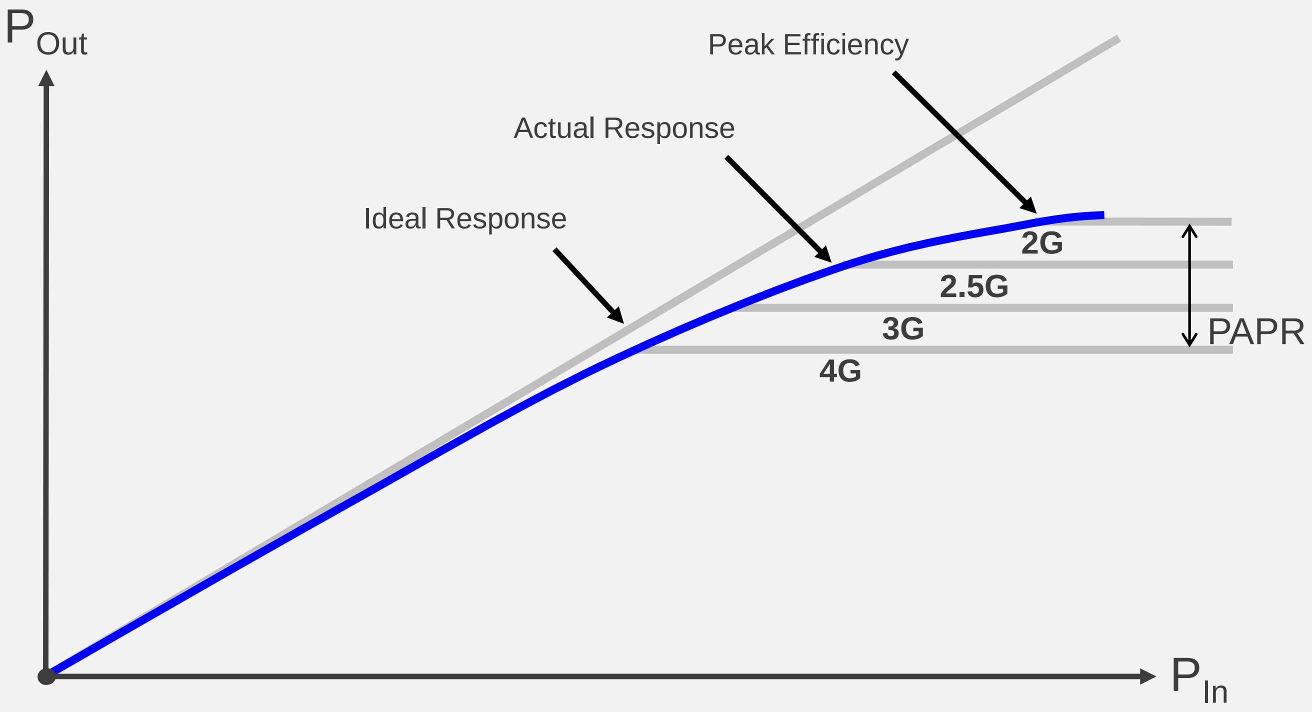
Multiple transceivers with single multi-band front-end module

DEMO: Develop a Sample Automated Test Sequence for a Typical Front-End Module Validation

- Create a 5G NR waveform with NI-RFmx Waveform Creator
- Address the DUT with MIPI RFFE and supply power with Digital Pattern Editor
- Confirm DUT functionality, manually test, and debug with InstrumentStudio
- Automate tests with an application development environment like LabVIEW
- Sequence numerous tests and generate reports with TestStand

NATIONAL INSTRUMENTS

Effects of Nonlinearity and High PAPR

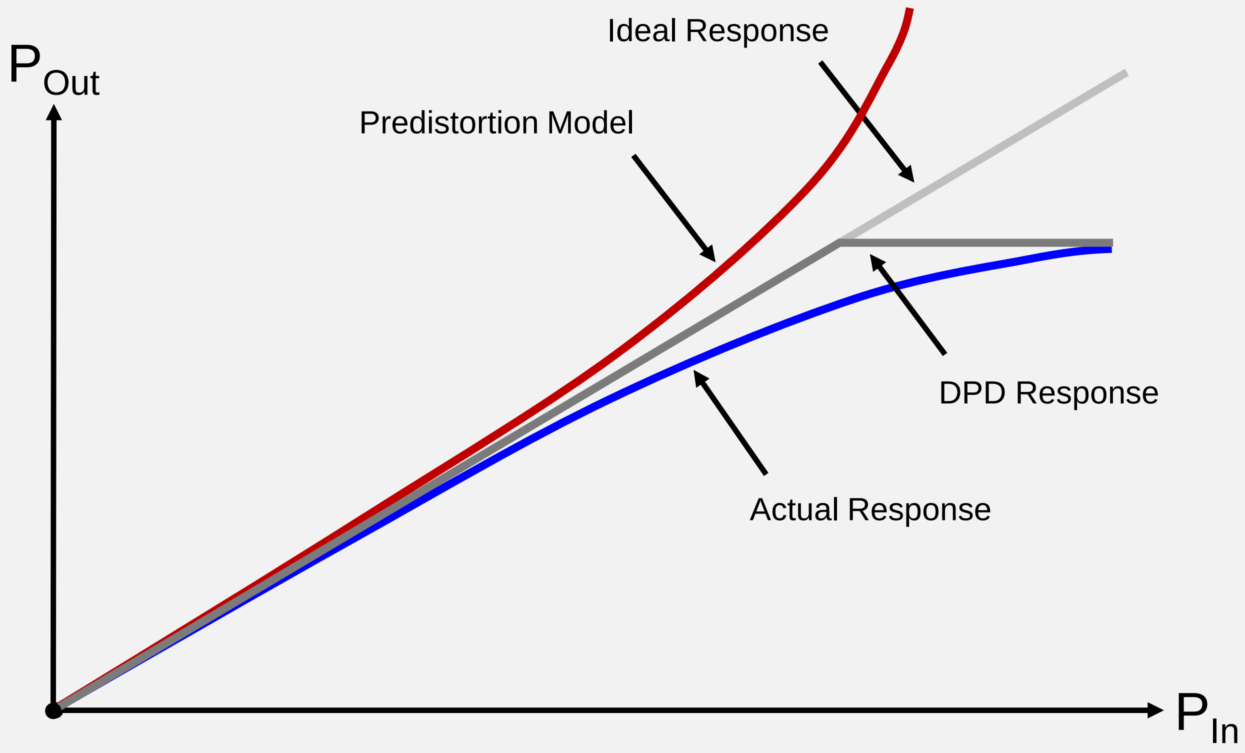


A nonlinear gain response introduces amplitude (AM-AM) and phase (AM-PM) distortion to signals with changing power over time.

This distortion increases for signals with higher peak to average power ratio (PAPR).

NATIONAL INSTRUMENTS™

Digital Predistortion (DPD)

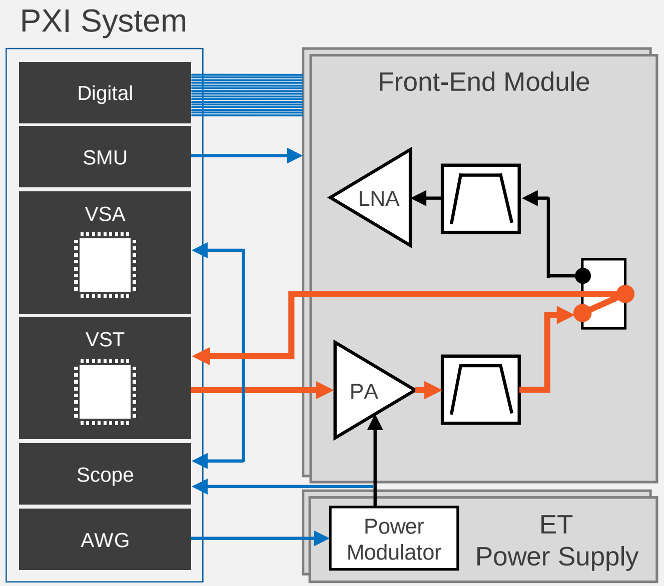


If the nonlinear response of a PA is known, we can predistort the input signal so that the resulting amplified signal is undistorted.

NI Front-End Module Test With DPD

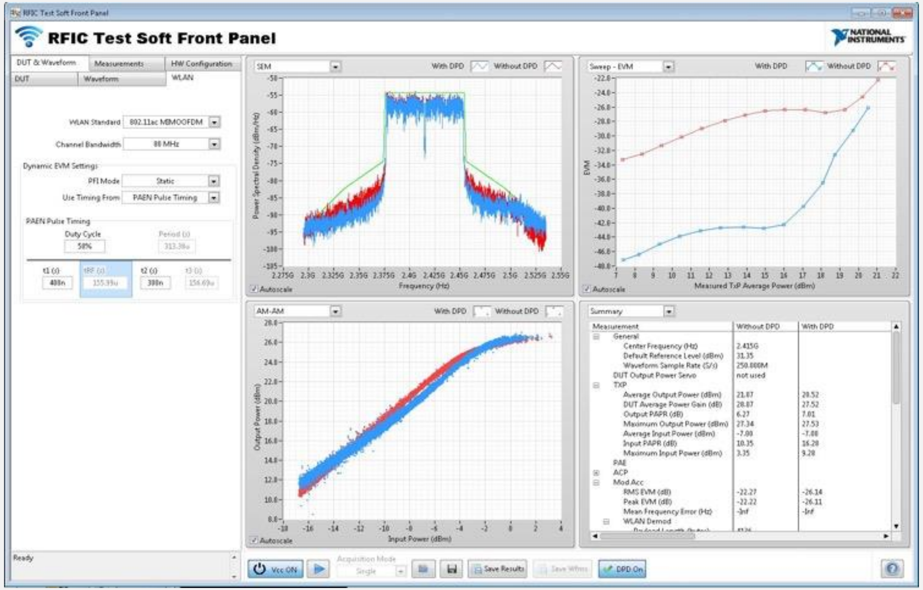
- VST with 1 GHz instantaneous generation and analysis bandwidth
- Free NI-RFmx SpecAn with LUT, MPM, and GMP DPD models
- Free RFIC Test Software with DPD automation examples

1. Generate reference waveform and acquire distorted waveform
2. Create predistortion model by comparing reference waveform to distorted waveform
3. Apply DPD to reference waveform using predistortion model
4. Generate predistorted waveform and make measurements



RFIC Test Software: Soft Front Panel

- High-level getting started experience for RFIC characterization/validation
- RFIC Test Soft Front Panel (SFP) built on LabVIEW for performing interactive RFIC characterization workflows



Demo Workflow

Initial Bring Up

- Bias the PA and confirm operation
- Create and generate a standard-compliant waveform
- Perform manual measurements to validate functionality

Code Module Development & Debug

- Develop code modules
- Debug code modules
- Automate individual code modules

Test Sequence Development & Deployment

- Build a test sequence to automate all code modules
- Run sequence, and begin data analysis

NI-RFmx Waveform Creator

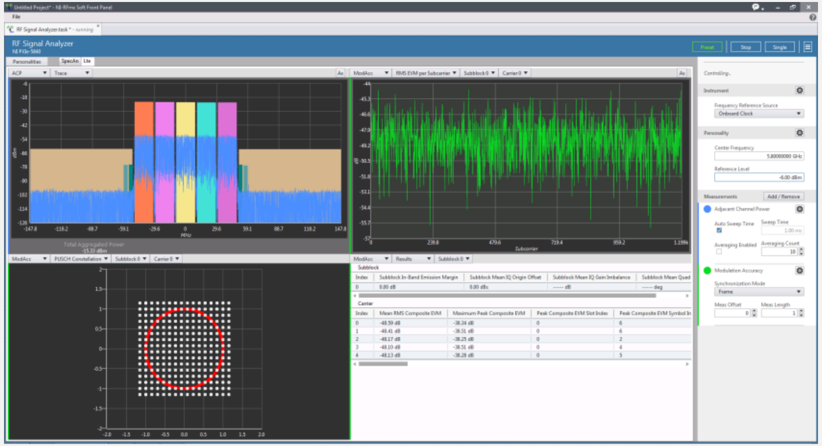
FEATURES AT A GLANCE

- Generate waveforms for cellular standards and general modulation schemes
- Create waveform files and playback on hardware
- Use unlocked, transferrable waveform files
- Apply IQ impairments to generation
- Included with NI-RFmx standards personalities

Simplify the development and debugging of automated RF test systems.

NI-RFmx Soft Front Panels

- Unified environment for RF standards
- Familiar and intuitive interactive experience
- Save and load configurations and data
- Debug automated test sequences
- Monitor automated test sequences

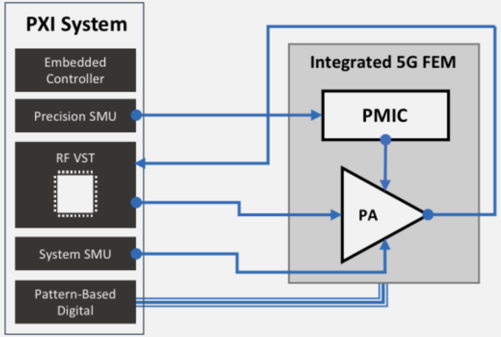


Industry-Standard Test Management Software

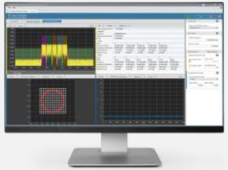
TestStand

FEATURES AT A GLANCE

- Author, execute, and debug test sequences
- Leverage test code developed in any language
- Test many devices in parallel
- Generate reports
- Integrate with databases
- Extend the software to meet custom requirements
- Develop professional operator interfaces



InstrumentStudio™

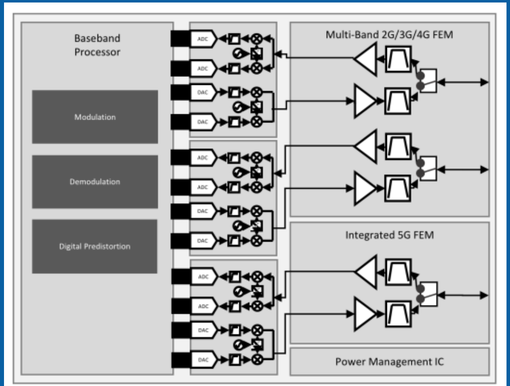


LabVIEW

NI Digital Pattern Editor

TestStand

InstrumentStudio™ LabVIEW™ Digital Pattern Editor NI TestStand™



Multiple transceivers with single multi-band front-end module

DEMO: Develop a Sample Automated Test Sequence for a Typical Front-End Module Validation

- Create a 5G NR waveform with NI-RFmx Waveform Creator
- Address the DUT with MIPI RFFE and supply power with Digital Pattern Editor
- Confirm DUT functionality, manually test, and debug with InstrumentStudio
- Automate tests with an application development environment like LabVIEW
- Sequence numerous tests and generate reports with TestStand

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SEMICONDUCTOR TEST

Skyworks

“Skyworks is pleased to be utilizing NI’s RF VST to validate performance of our Sky5™ solutions for 5G NR applications.”

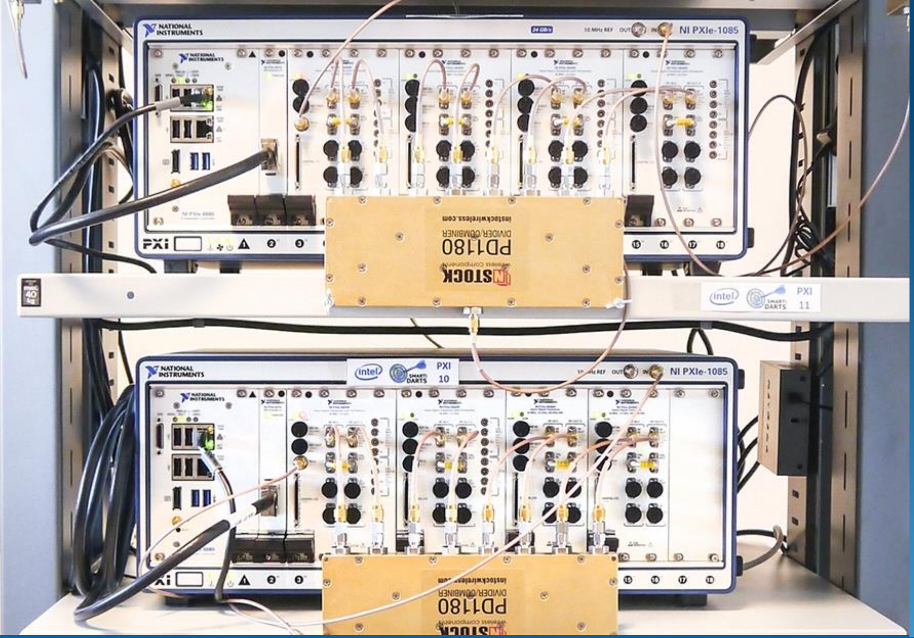
-Kevin Walsh, Director of Mobile Marketing, Skyworks

SEMICONDUCTOR TEST

QORVO

“The wide bandwidth, excellent RF performance, and the flexibility of NI’s PXI test system were critical in helping us introduce the industry’s first commercially available 5G FEM.”

--Paul Cooper, Director of Carrier Liaison and Standards
Qorvo Mobile Products



Achieved 5X faster test times

Reduced tester footprint by 50%

Saved several million $$$

“The measurement speed of PXI was very attractive to us. In fact, the VST’s measurement speed was about 5 times faster than our previous test equipment. This has allowed us to cut the characterization time for a typical LTE modem from one week to less than 2 days…With the additional testing that we were able to perform using PXI, we estimate that we have saved several million dollars.”

—Eike Ruttkowski, Head of RF Cellular Hardware, Intel

Summary

Evolving wireless standards, higher levels of integration, and new technologies require new test approaches for characterizing modern PAs/FEMs.

PXI is the ideal platform for RFIC characterization and production test:

- Faster measurements to address growing number of test cases
- Wide range of fast DPD algorithms combined with the ability to use custom algorithms
- Tight PXI instrument synchronization, which is necessary for envelope tracking PAs/FEMs
- Wide availability of PXI instruments (VST, SMU, digital, and more) that enables engineers to configure a complete PXI test bench in one chassis

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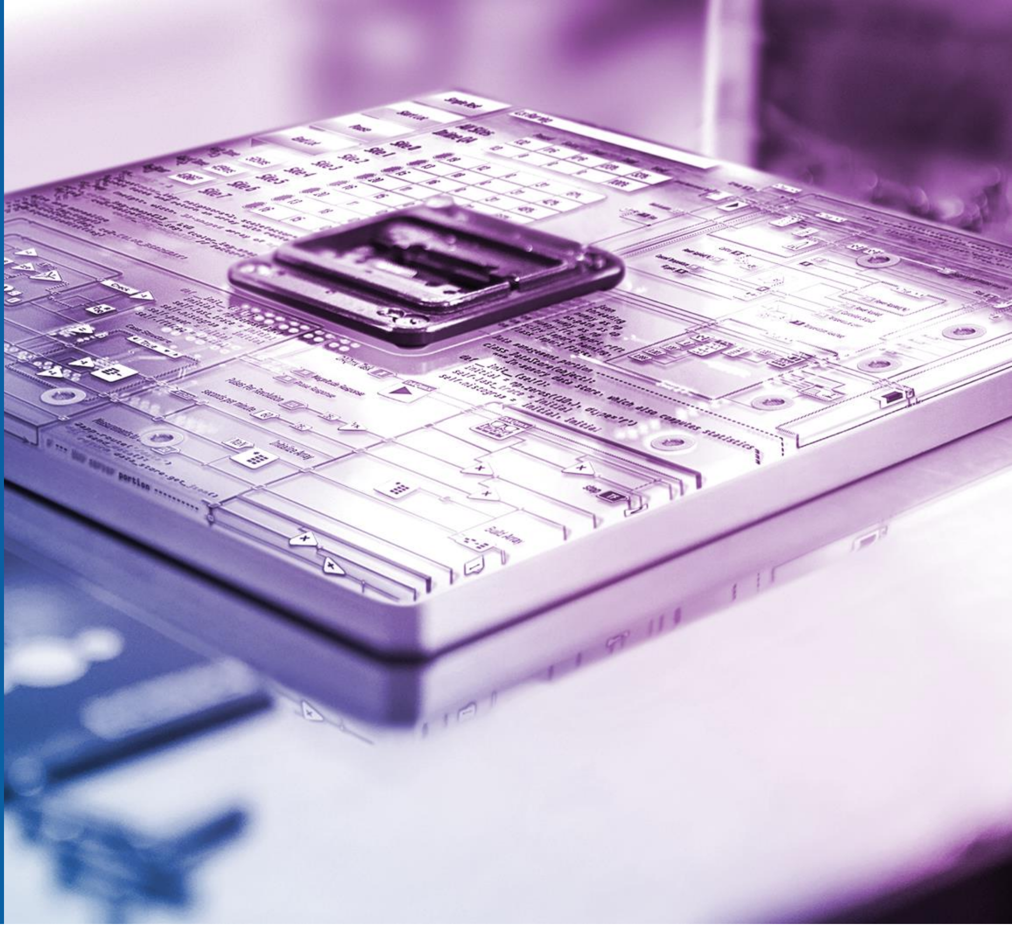
Agenda

Time	Topic	Presenter	Demo
9:00	**Welcome and Introductions**		
9:15	**Lower the Cost of Test While Improving Time to Market with Better Cross-Functional Workflows**	Joshua Young	No
10:00	**Introduction to the PXI Platform**	Tarek Safwan	No
10:30	**Using a Modular Platform for Mixed-Signal Semiconductor Characterization** • Use InstrumentStudio™ to save project configurations, export measurement results, monitor instruments and perform interactive debugging • See how the digital capability of semiconductor ATE systems can be replicated with a lab-friendly footprint • Live demonstration of DUT characterization using modular instruments	Tarek Safwan	Yes
12:00	**Lunch/Networking**		
13:00	**Using a Modular Platform for RFIC Semiconductor Characterization**	Mher Minasyan	Yes
13:30	**RF Measurement Optimization with RFmx**	Mher Minasyan	Yes
14:15	**Beyond Bluetooth 5**	Mher Minasyan	Yes
14:45	Wrap-up and summary	All	

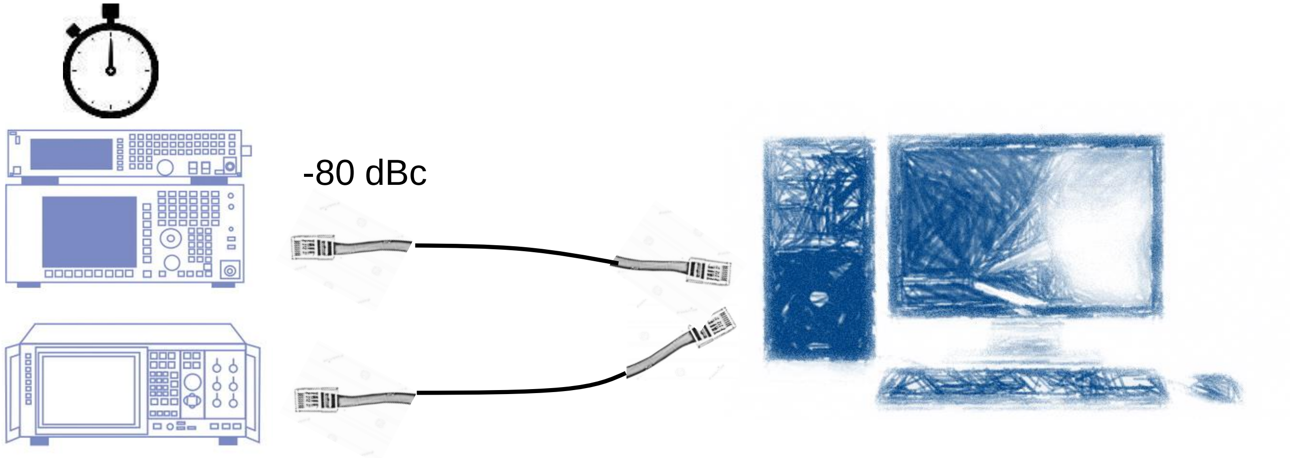
RF Measurement Optimization with NI RFmx

Smarter Test From
Characterization to Production



Mher Minasyan
Applications Engineer
National Instruments

Traditional Method of Programming



Programming Environment

Read: ACP Measurement

Why are we still programming this way?

- Takes Too Long
- Instrument returns data only after processing is done
- Parallel Processing
- Processor Technology ?

NI-RFmx Makes Complex RF Measurements Simple

Usability

Measurement-Focused
Integrated Software Package with NI-RFSA For Faster Software Development.

Intuitive Example Programs
LabVIEW, .NET,
LabWindows™/CVI, and C

Guiding Documentation
Measurement focused documentation that helps test engineers solve RF test applications

Speed & Performance

Highly Parallel
Easy-to-program parallel measurements
- Composite
- Overlapped Measurements

Fast
Industry-leading measurement speeds
- Marker Mode for fastest EVM on the Market

High Performance
Automatic Optimization for Specific Hardware Target
- Best-In-Class Dynamic Range
- Best-In-Class EVM Measurements

Interoperability

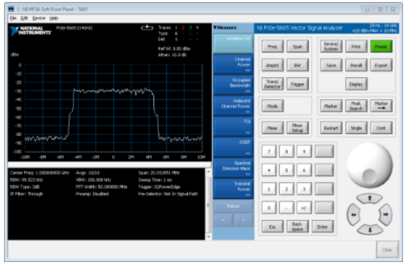
Spectrum Analysis
common Spectral Measurements
CHP, ACP, Harmonics, DPD, AMPM, TXP, CCDF, SEM, OBW…

Digital and Analog Modulation
AM, FM, PM
ASK, FSK, PSK, QAM, MSK

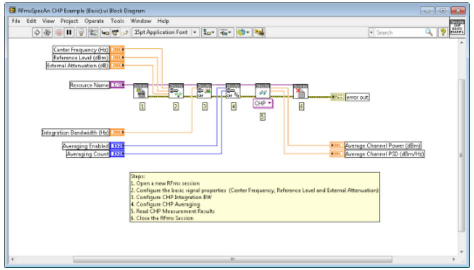
Cellular Standards
LTE-Advanced, LTE, UMTS, GSM/EDGE, CDMA2K, TDSCDMA, EVDO

NI-RFmx Architecture

Soft Front Panel



NI-RFmx Measurement API



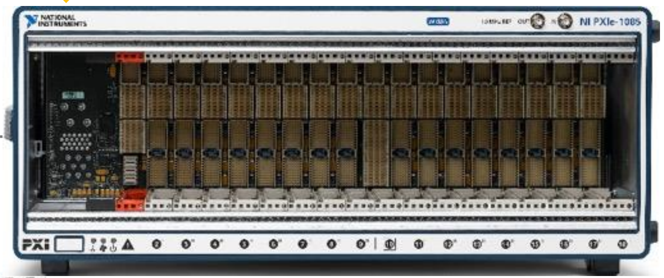
NI-RFmx

Software

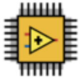
NI-RFSA

Hardware

PXI Platform



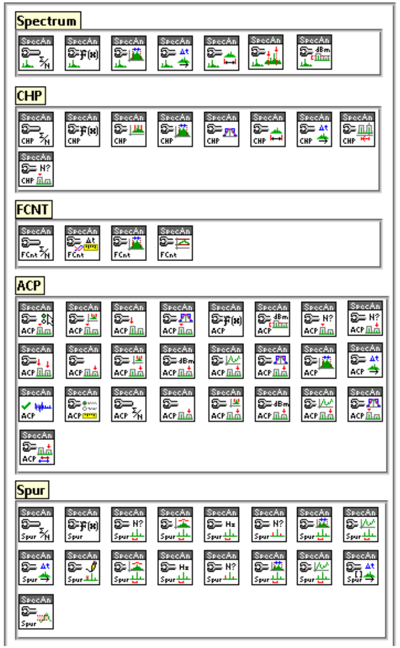
PXI RF Instrument



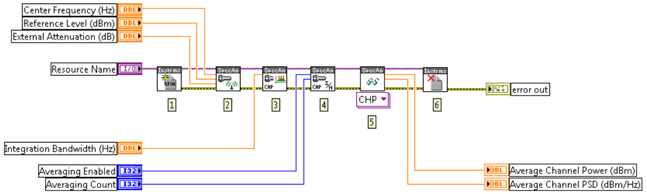
LabVIEW FPGA

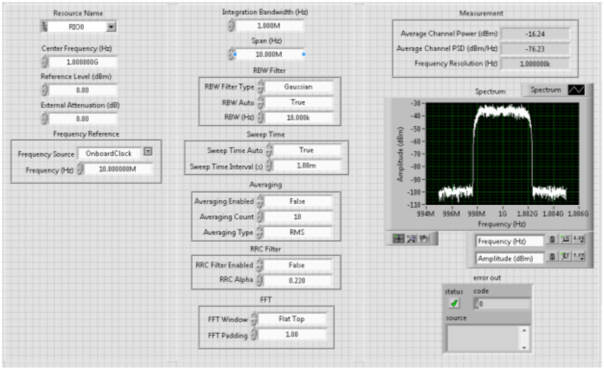
NI-RFmx Usability

Measurement-Focused API



Intuitive Examples



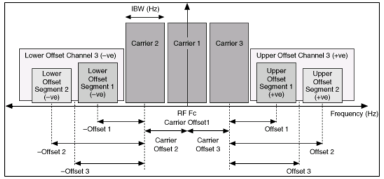


Guiding Documentation

Theory

Adjacent Channel Power (ACP) Overview

ACP measurement measures the power leakage from the carrier channels into the neighboring frequency channels, commonly referred to as offset channels. The following figure shows a typical carrier channel and offset channel configuration.



Carrier Channels

Carriers are channels in which significant power is transmitted, and for which power leakage in the offset channels are to be measured. Multiple carriers are configured relative to the RF center frequency by specifying the carrier offset, integration bandwidth (IBW), and root raised cosine (RRC) channel filter. Power in each carrier is measured by integrating the power in the specified IBW after applying the channel filter. The total carrier power measured is the aggregate power of all the active carriers. To exclude a carrier in the total carrier power, set the carrier to passive mode.

API Details

RFmxSpecAn Read (VI)

Owning Palette: SpecAn

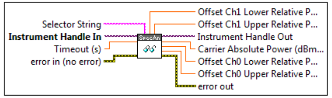
Configures hardware for acquisition, performs measurement on acquired data, and returns measurement results.

Use the pull-down menu to select an instance of this VI.

Select an instance

RFmxSpecAn ACP Read

Configures hardware for acquisition, performs measurement on acquired data, and returns the adjacent channel power (ACP) measurement results.



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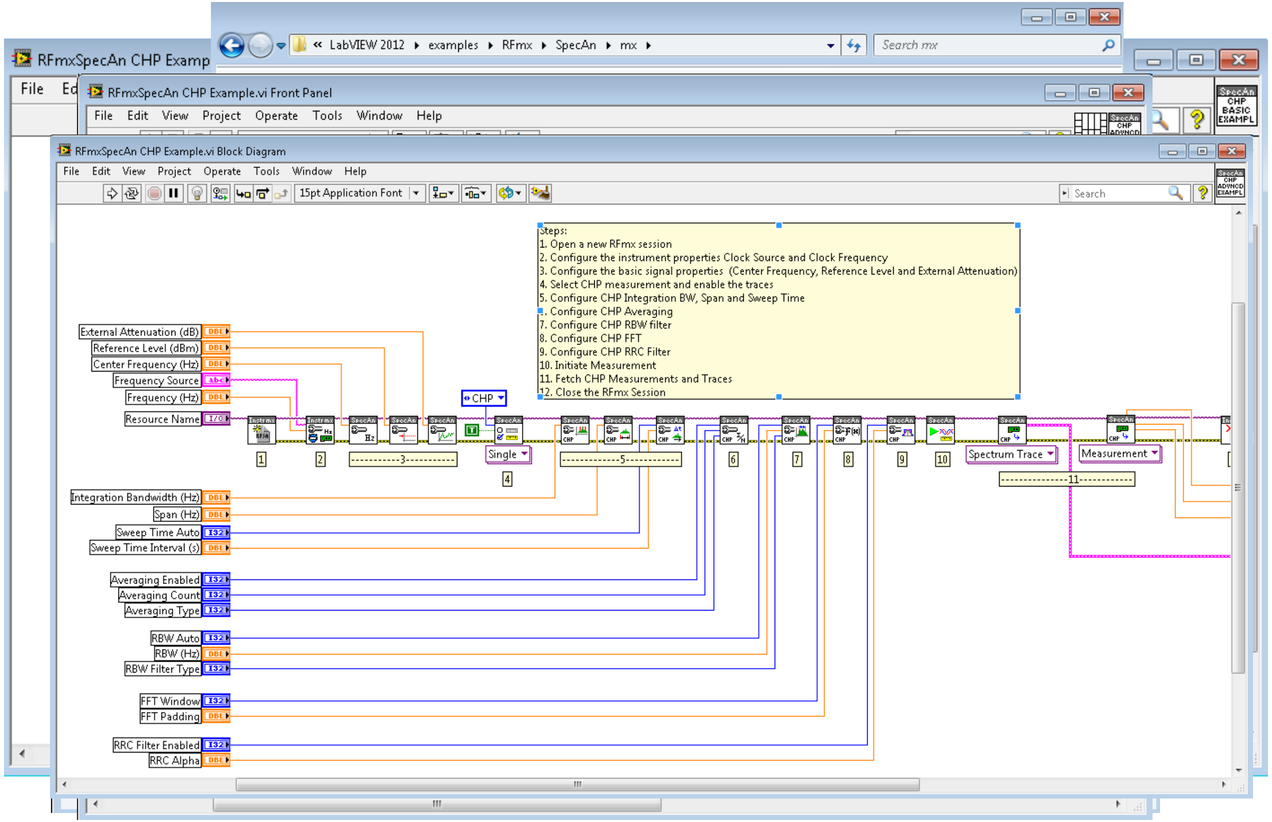
Using NI-RFmx Example Programs



Easy to program API (.NET)

Basic and Advanced examples for all supported measurements

```
internal void Run()
{
    string resourceName = "RFSA";
    double centerFrequency = 1e+9;          /* Hz */
    double referenceLevel = 0.00;           /* dBm */
    double externalAttenuation = 0.00;      /* dB */
    double timeout = 10.0;                  /* seconds */
    double integrationBandwidth = 1.0e+6;   /* Hz */
    RFmxSpecAnMXChpAveragingEnabled averagingEnabled = RFmxSpecAnMXChpAveragingEnabled.False;
    int averagingCount = 10;
    double absolutePower;                /* dBm */
    double psd;             /* dBm/Hz */

    try
    {
        /* Create a new RFmx Session */
        instrSession = new RFmxInstrMX(resourceName, "");

        /* Get SpecAn signal */
        specAn = instrSession.GetSpecAnSignalConfiguration();

        /* Configure measurement */
        specAn.ConfigureRF("", centerFrequency, referenceLevel, externalAttenuation);
        specAn.Chp.Configuration.ConfigureIntegrationBandwidth("", integrationBandwidth);
        specAn.Chp.Configuration.ConfigureAveraging("", averagingEnabled, averagingCount, RFmxSpecAnMXChpAveragingType.Rms);

        /* Retrieve results */
        specAn.Chp.Results.Read("", timeout, out absolutePower, out psd);

        Console.WriteLine("Absolute Power (dBm) {0}\n", absolutePower);
        Console.WriteLine("PSD (dBm/Hz) {0}\n", psd);

    }
    catch (Exception ex)
    {
        DisplayError(ex);
    }
```

Initialize VSA

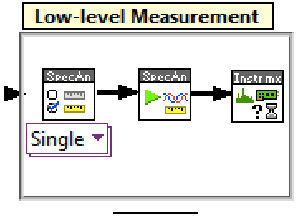
Define Measurement Signal

Measurement Configuration

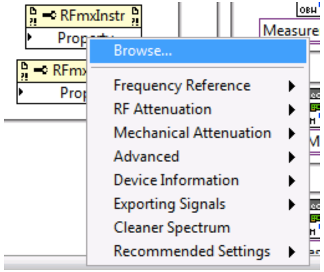
Acquire Analyze Fetch Results

Exposing Low Level Capabilities

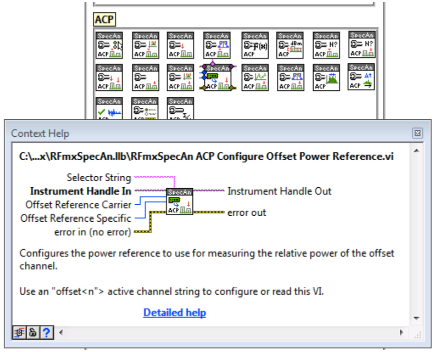
Fetch Capabilities



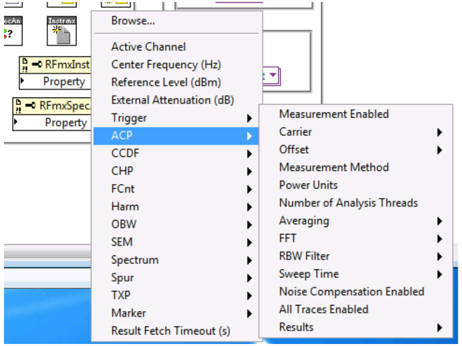
RF Instrument Property Nodes



Measurement Settings

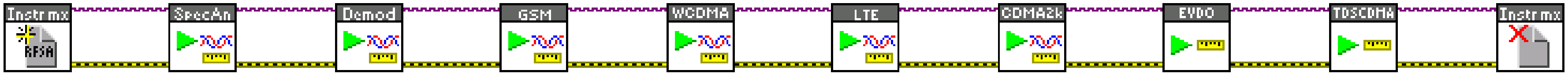


Measurement Property Nodes

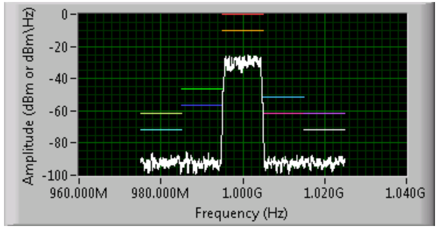


RFmx Is Interoperable:

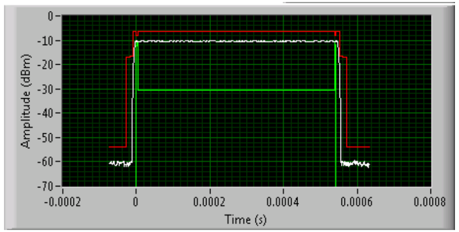
One Session Multiple Personalities: SpecAn, Demod, Cellular



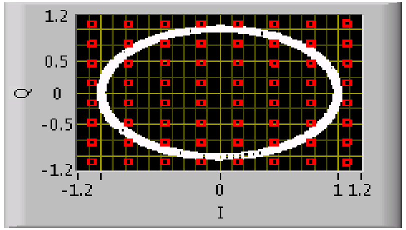
Spectrum Trace



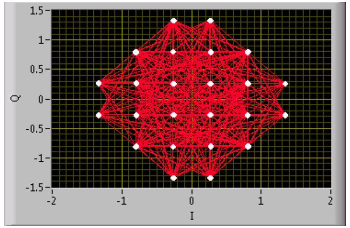
GSM Power Vs Time



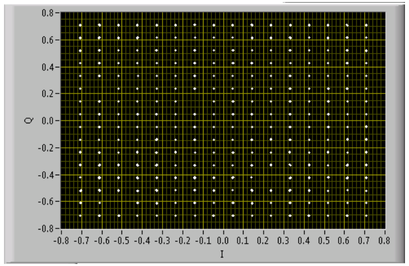
LTE Constellation



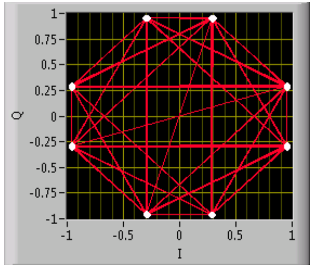
EV DO Constellation



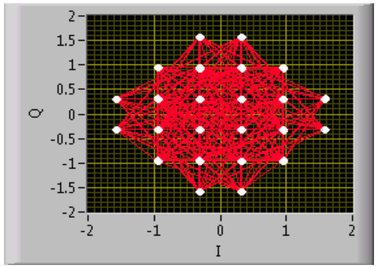
256 QAM Constellation



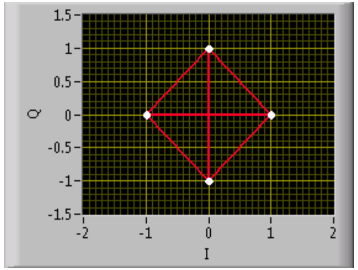
WCDMA Constellation



CDMA2K Constellation

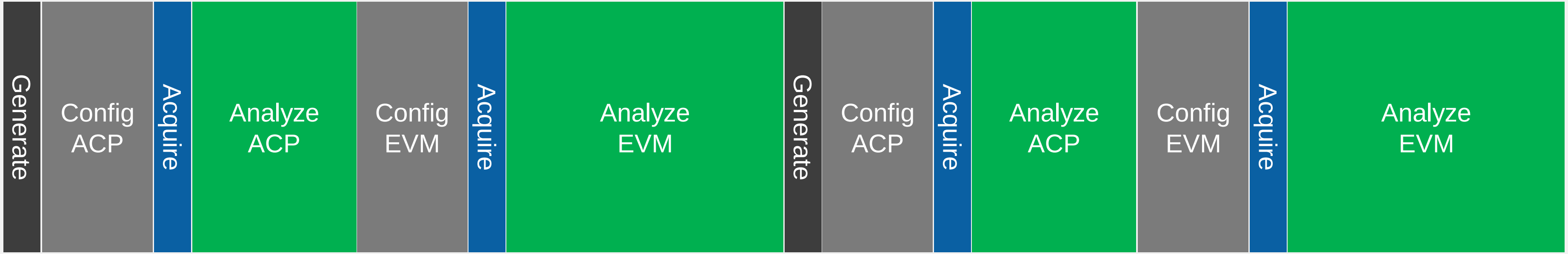


TDS CDMA Constellation



Reducing Test Times With NI-RFmx

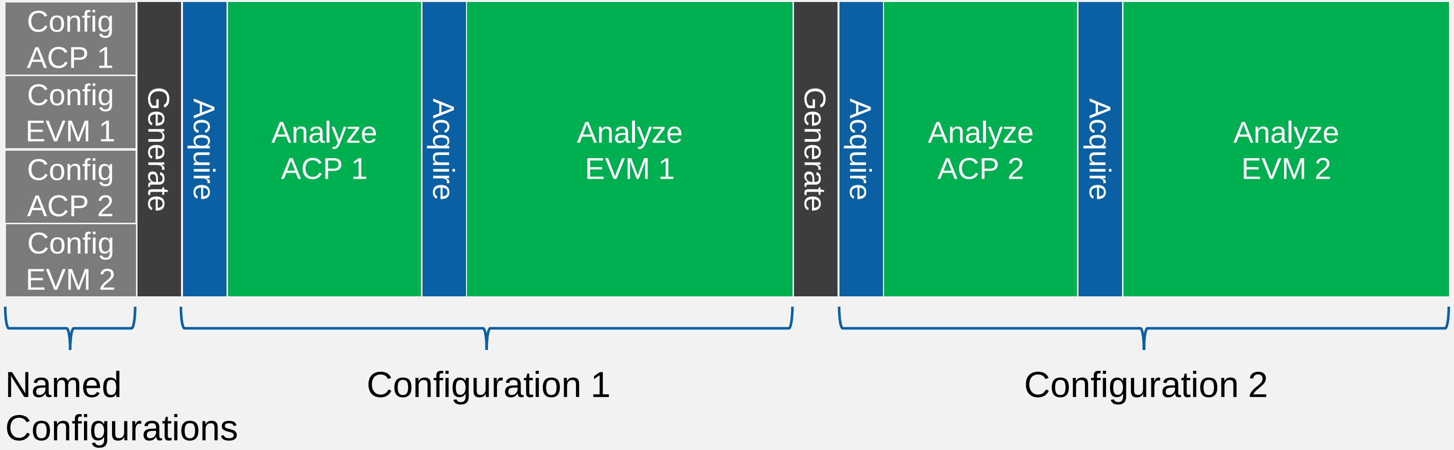
Traditional Approach: Serialized Execution



- Majority of the time is spent in software; hardware is underutilized
- Takes limited advantage of multicore CPU multithreading capabilities and large amounts of memory

Reducing Test Times With NI-RFmx

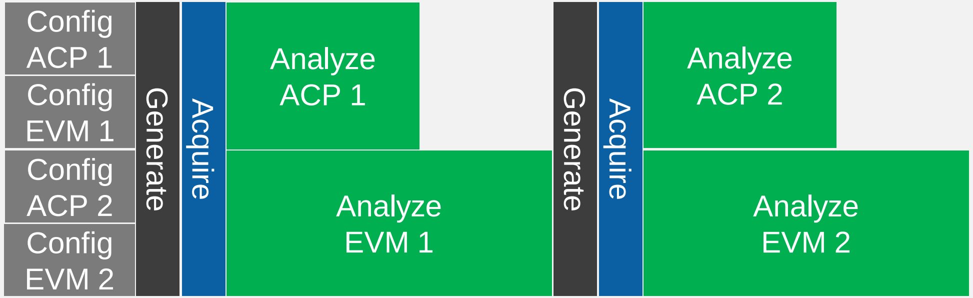
NI-RFmx Approach: Signal Configurations



- Create named signal configurations prior to measurements
- Initiate each measurement with a different configuration

Reducing Test Times With NI-RFmx

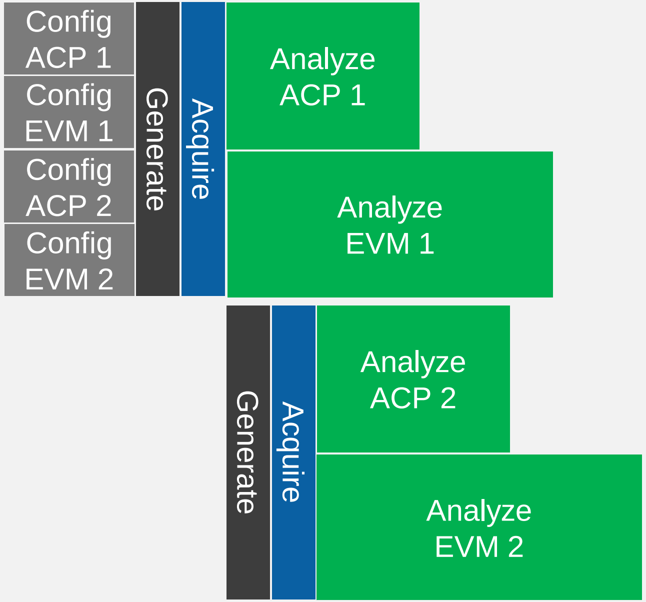
NI-RFmx Approach: Composite Measurements



- Perform a single acquisition for all measurements
- Analyze measurement results in separate threads

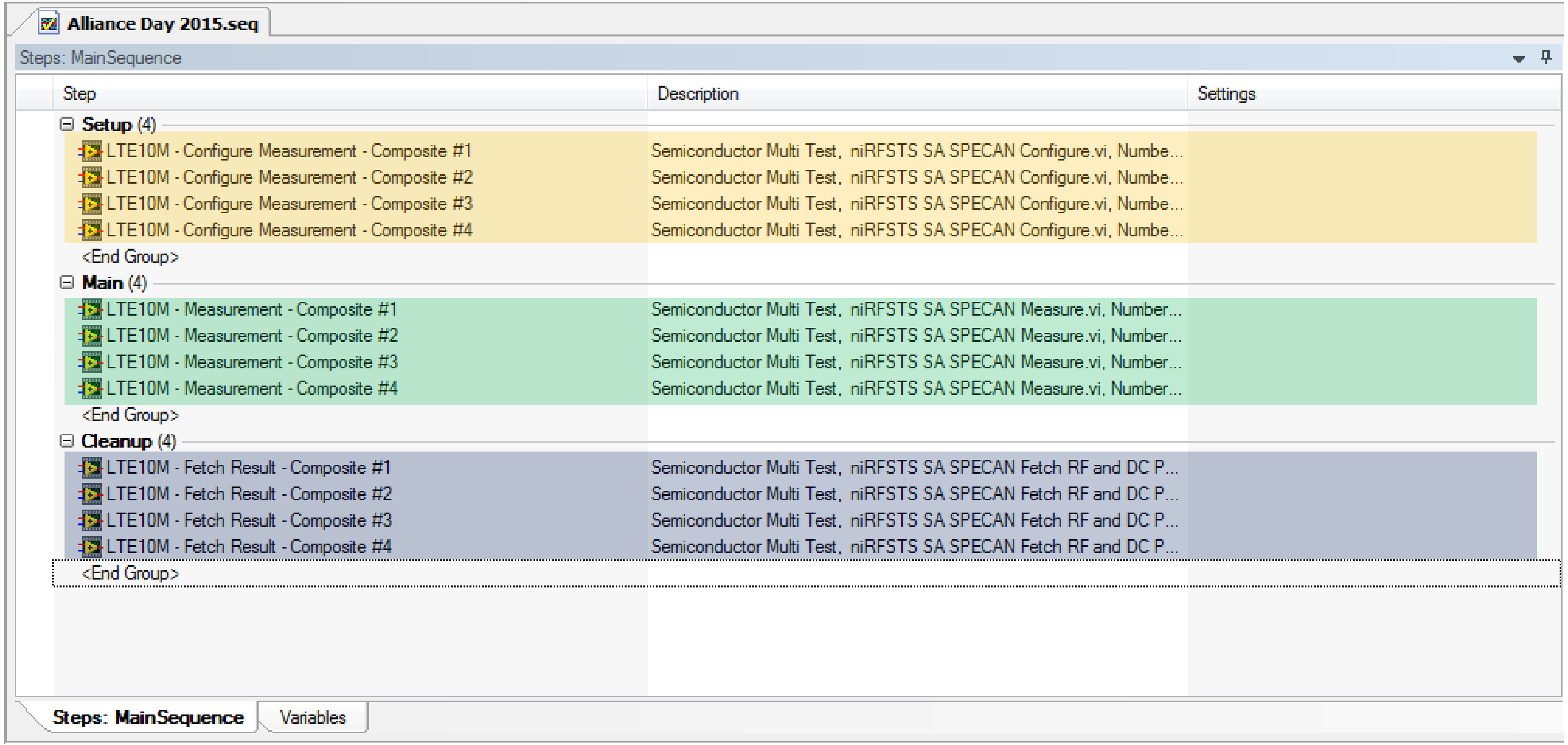
Reducing Test Times With NI-RFmx

NI-RFmx Approach: Overlapped Measurements



- Pipeline measurements with asynchronous analysis and results fetching
- Reduces test times by 2X–5X

Overlapping In TestStand



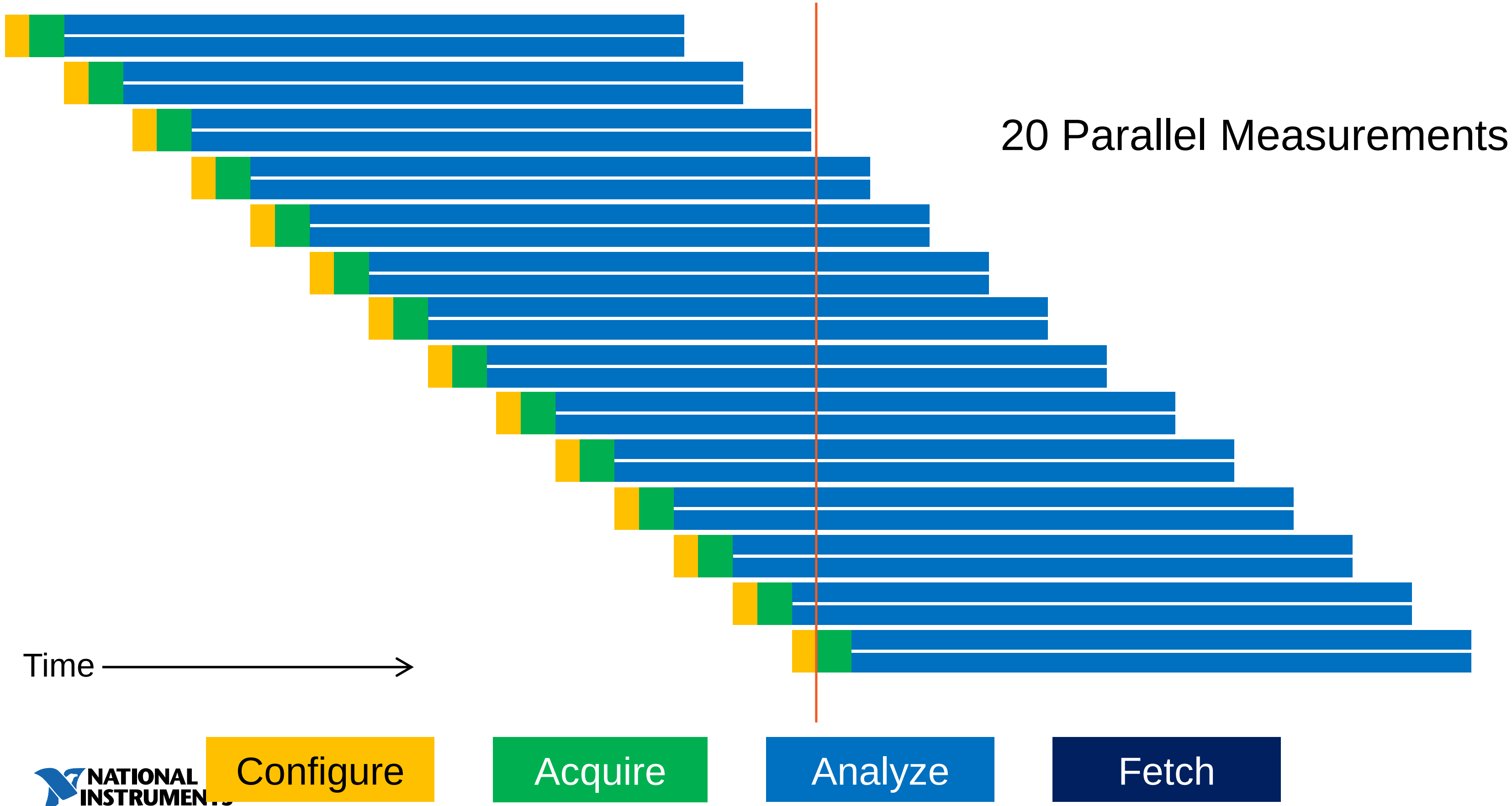
Configure

Acquire

Analyze

Fetch

Keeping the System Busy



Keeping the System Busy (PXIe-8135)

# of Measurements	Method	Processor %	Total Time (Seconds)	Speed Up
1	Serial	12	2.4	
5	Serial	12	12.3	
20	Serial	12	49.1	
50	Serial	12	122.7	
5	Parallel	66	3.9	3.15X
20	Parallel	100	10.2	4.8X
50	Parallel	100	30.0	4X

<u>Conditions</u>

NI-RFmx 1.2, PXIe-8135, LabVIEW 32 bit, 4096 QAM EVM

Keeping the System Busy (PXIe-8880)

# of Measurements	Method	Processor %	Total Time	Speed Up
1	Serial	12%	2.4 S	
5	Serial	12%	11.8 S	
20	Serial	12%	47.5 S	
50	Serial	12%	118.6 S	
5	Parallel	64%	3.5 S	3.3X
20	Parallel	100%	8.3 S	5.7X
50	Parallel	100%	18.9 S	6.2X

<u>Conditions</u>

NI-RFmx 1.2, PXIe-8880, LabVIEW 32 bit, 4096 QAM EVM

Where Else Can We Get Faster ?

Faster Servo
- FPGA
- DUT-Specific-Algorithm

Faster Analysis
- Coprocessor (PXImc or FPGA)

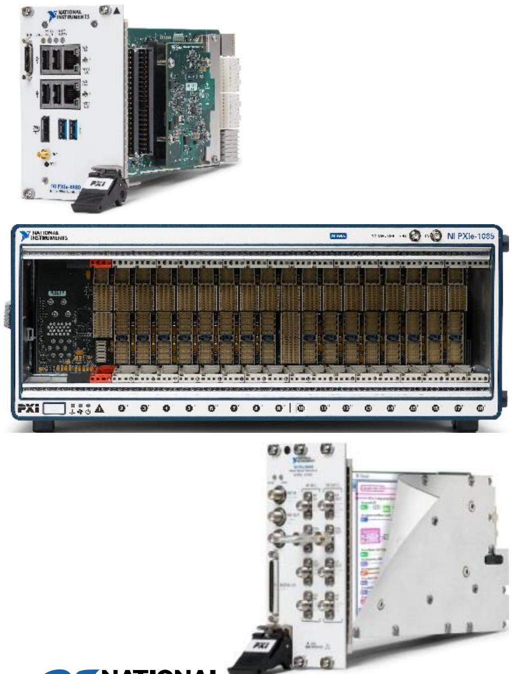
Shorter Acquisition
- Stimulus-Response-Triggering
- Low-Noise-DUT

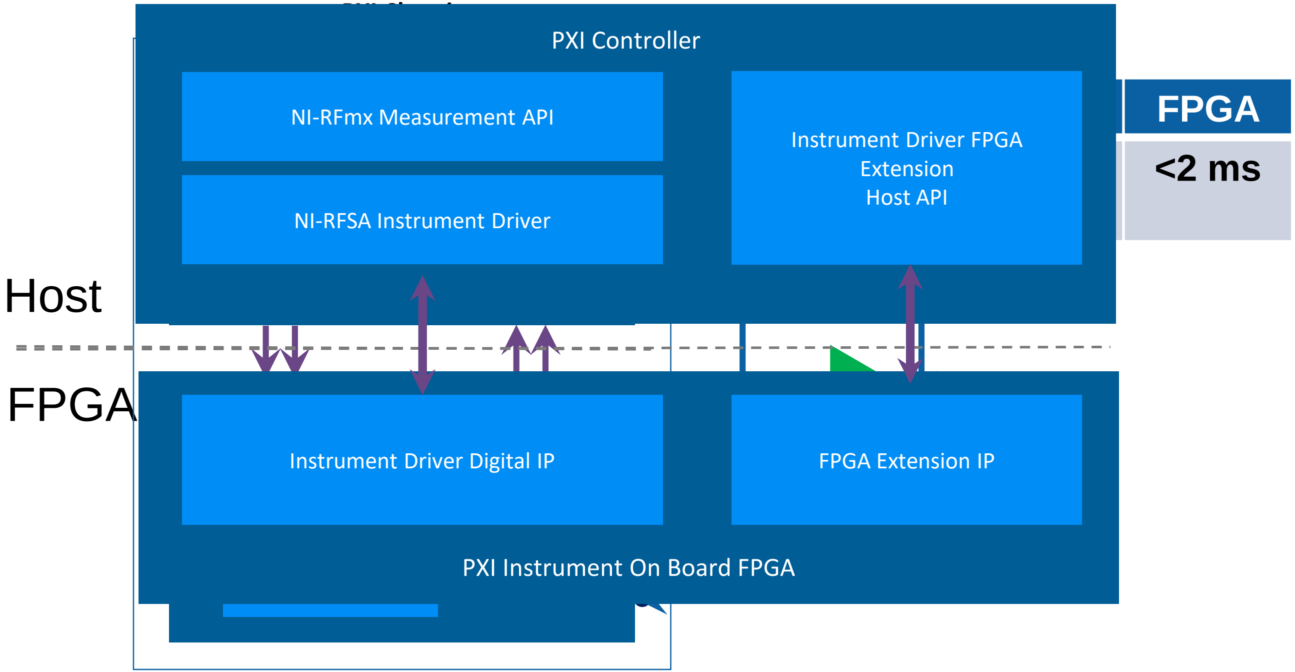
Time →

Configure Acquire Analyze Fetch

Instrument Driver FPGA Extensions

- NI-RFmx Preserves usage of Instrument Drive FPGA Extensions





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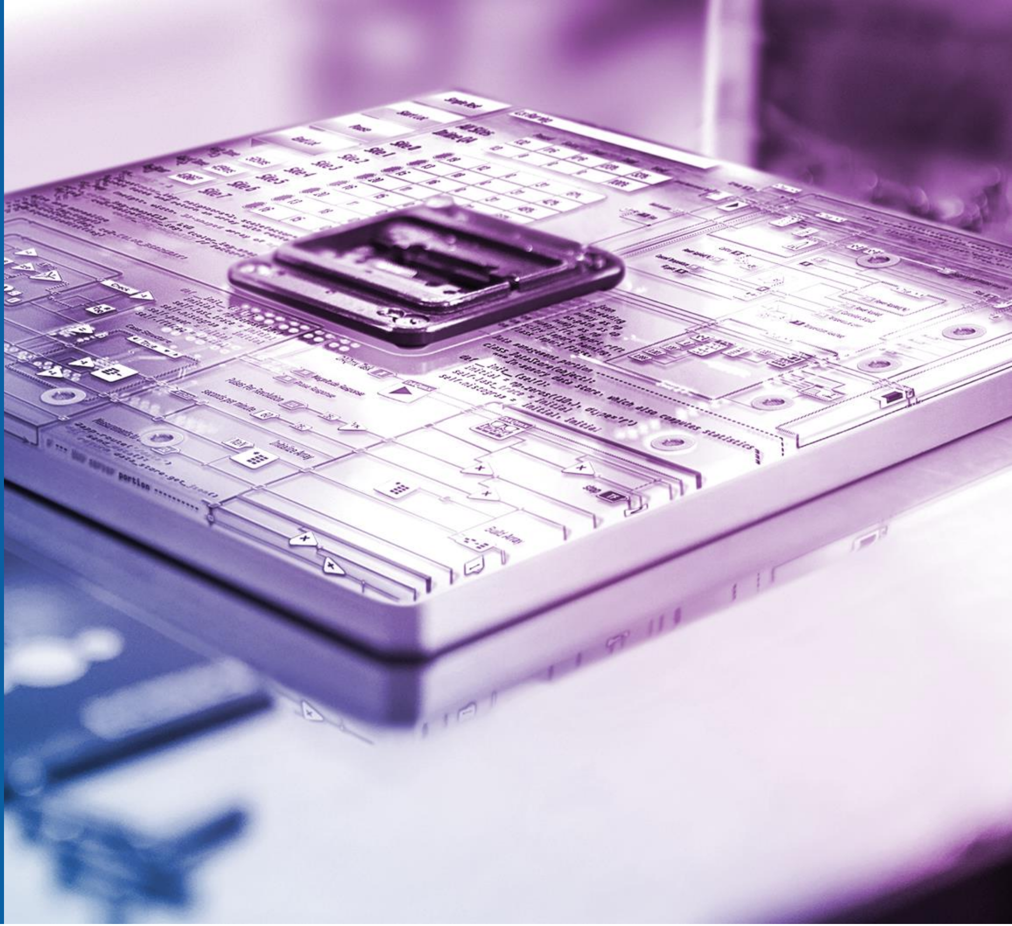
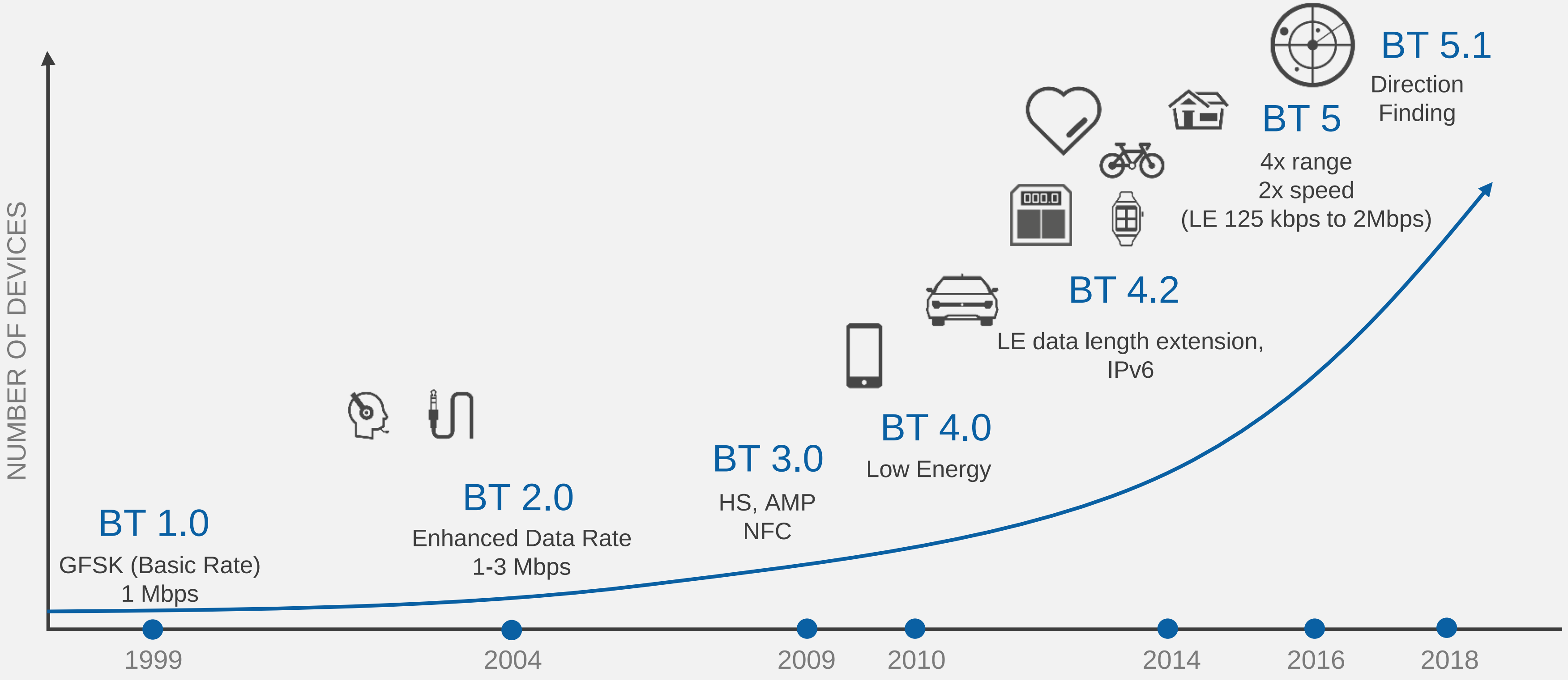
Beyond Bluetooth 5

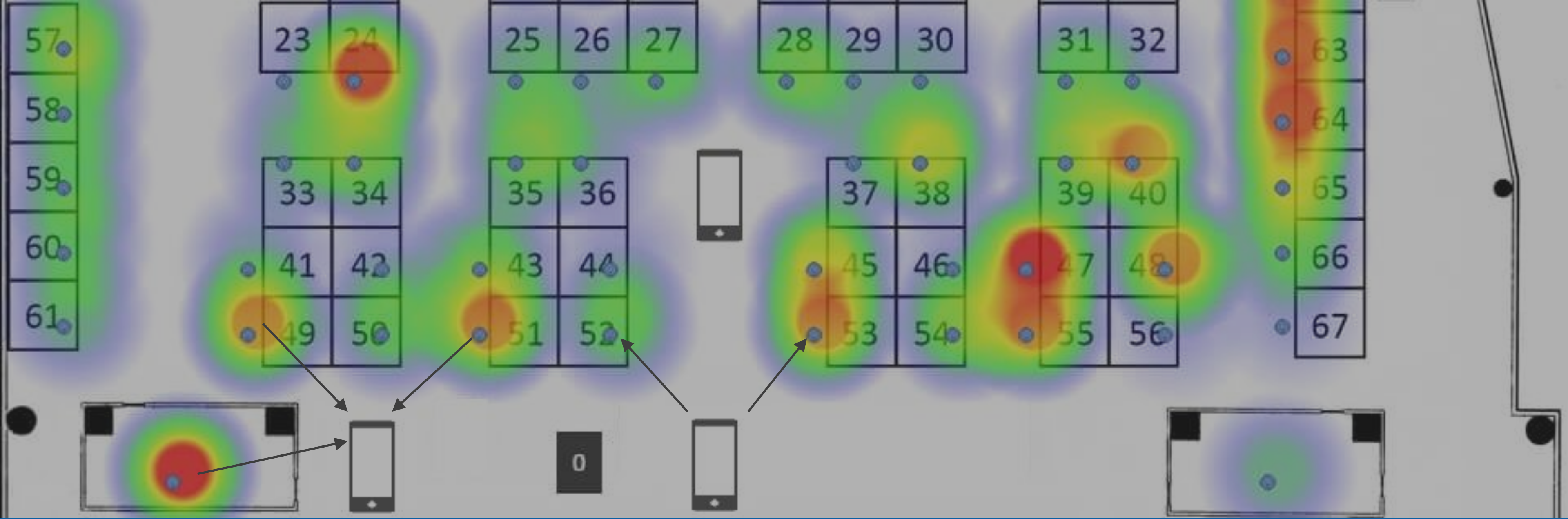
Smarter Test From Characterization to Production

Mher Minasyan
Applications Engineer
National Instruments



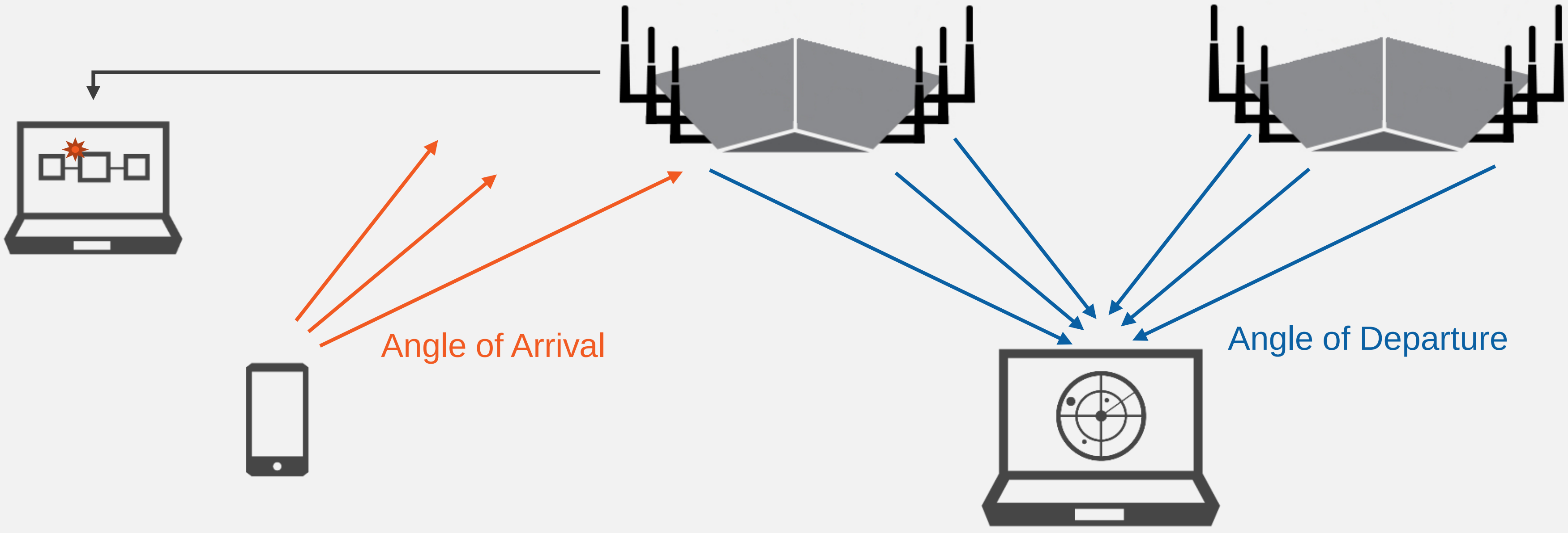
Bluetooth Evolution





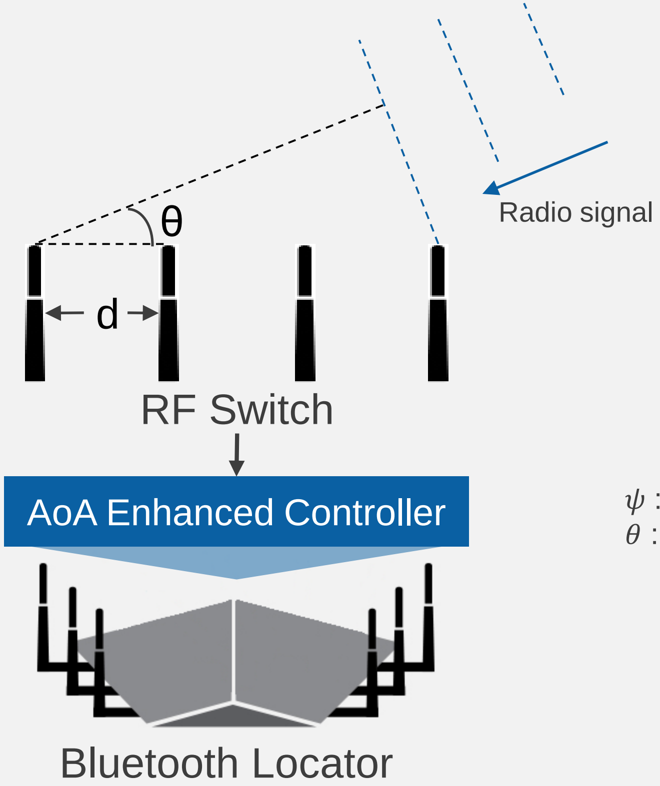
Bluetooth 5.1
Direction Finding Using BTLE

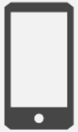
Bluetooth 5.1 Direction Finding Applications



Indoor Positioning | Asset Tracking | Direction Tracking | Directional Services

Angle of Arrival (AoA)





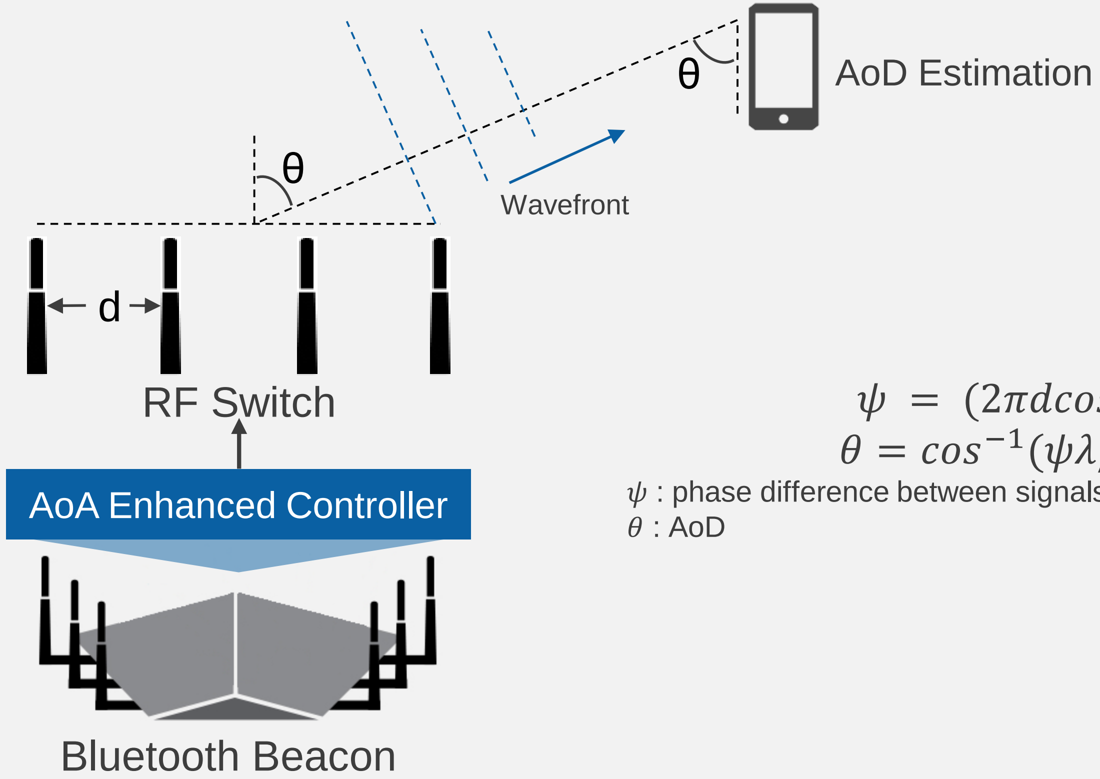
AoA Enhanced Controller

$$\psi = (2\pi d \cos\theta)/\lambda$$
$$\theta = \cos^{-1}(\psi\lambda/2\pi d)$$

ψ : phase difference between signals from different antennas
θ : AoA

Bluetooth SIG AoA/AoD specifications mature but not yet final

Angle of Departure (AoD)

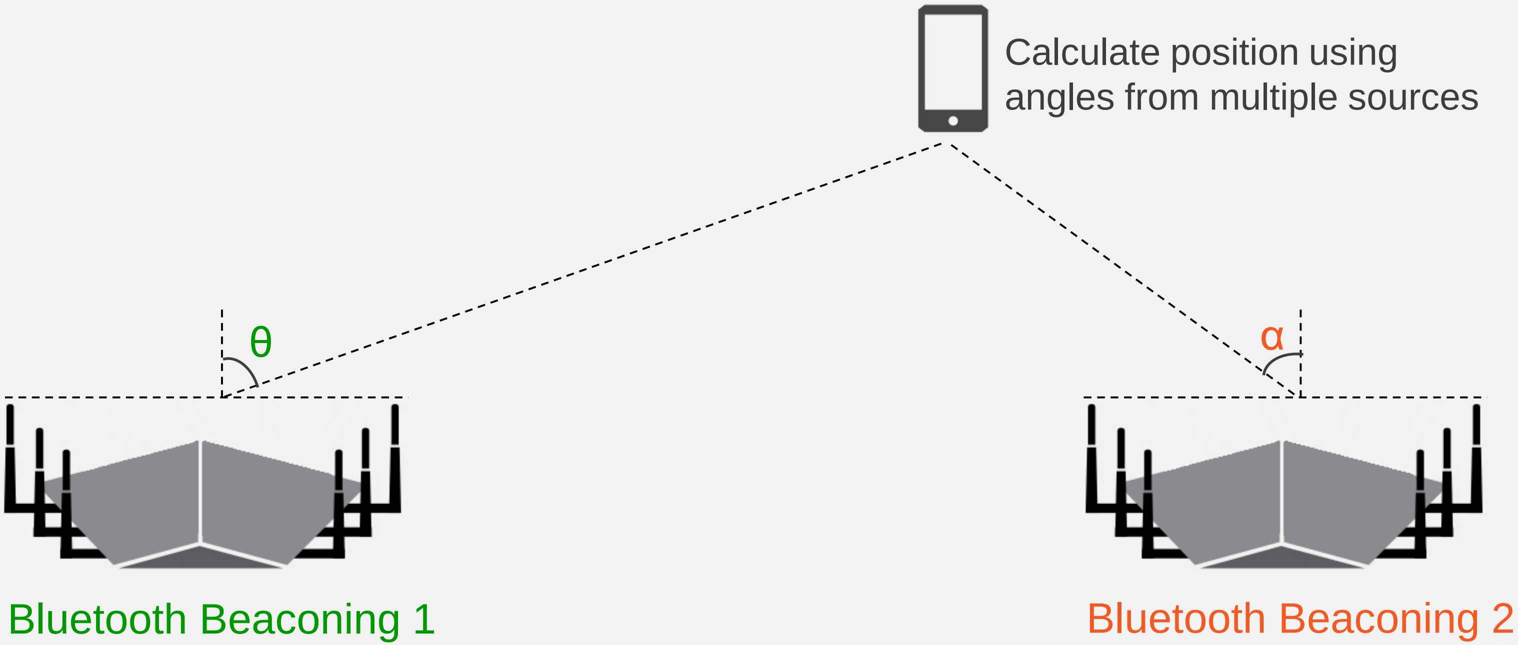


$$\psi = (2\pi d cos\theta)/\lambda$$
$$\theta = cos^{-1}(\psi\lambda/2\pi d)$$

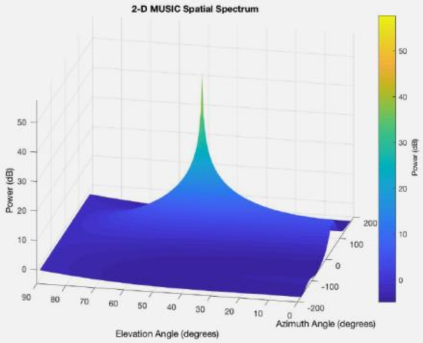
ψ : phase difference between signals from different antennas
θ : AoD

Bluetooth SIG AoA/AoD specifications mature but not yet final

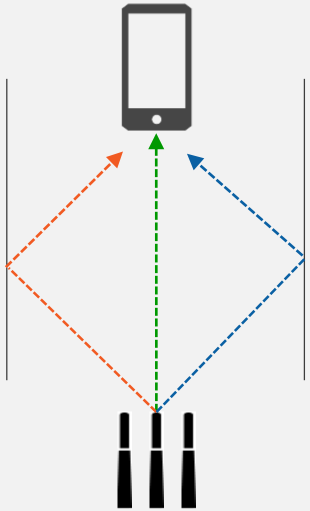
Angle of Departure (AoD)

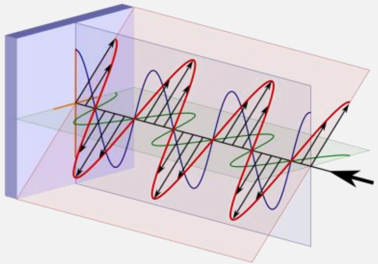


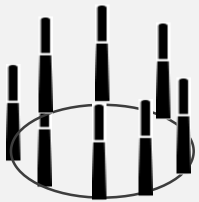
Direction Finding Challenges



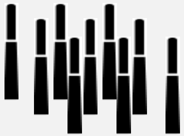
$$P(\theta) = \frac{1}{a^H(\theta)VV^Ha(\theta)}$$



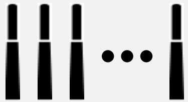




Uniform Circular Array (UCA)



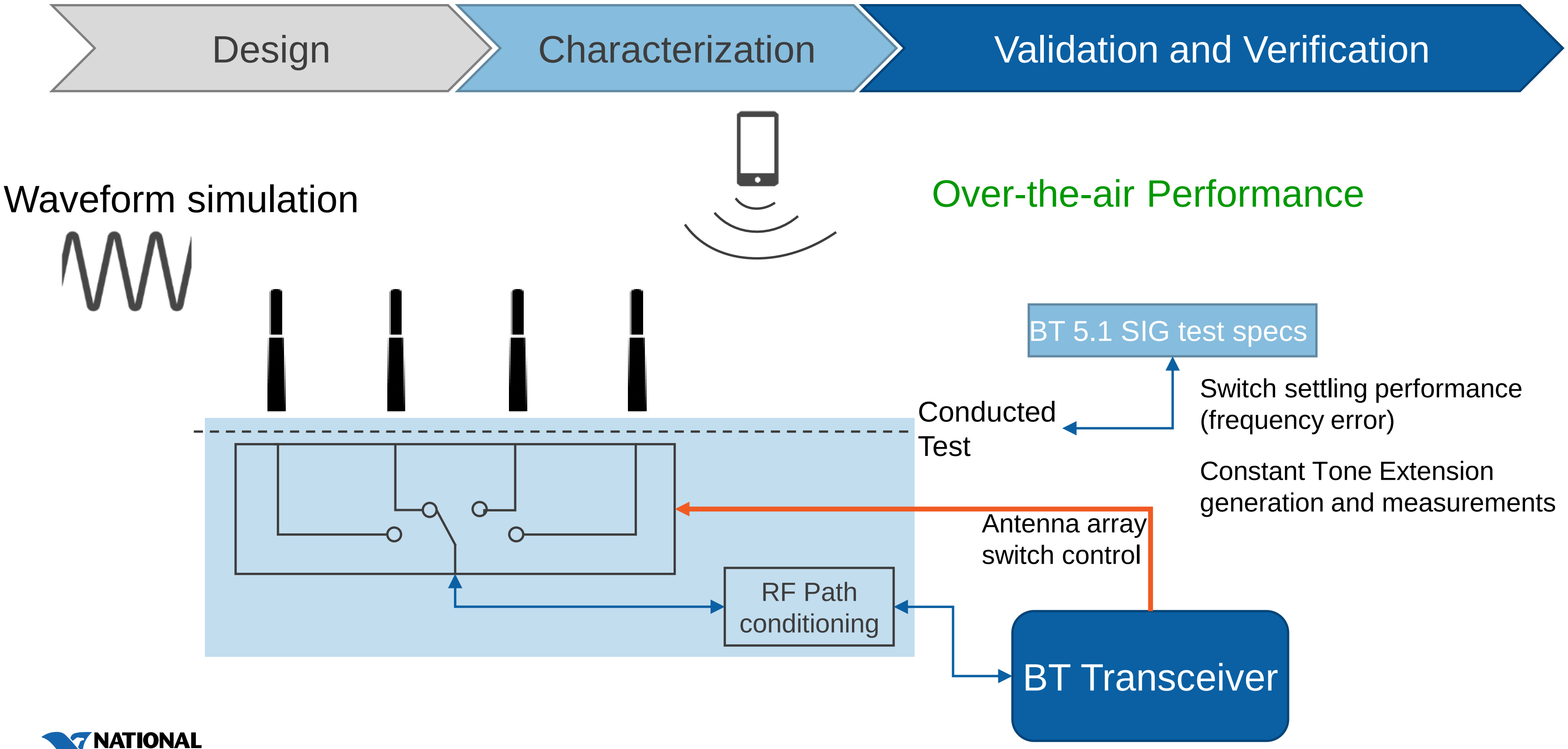
Uniform Rectangular Array (URA)



Uniform Linear Array (ULA)

Algorithms/Processing | Multipath | Polarization | Antenna size

Characterization and Validation Test Challenges



NI Bluetooth Measurements

Packet Types in Bluetooth Toolkit

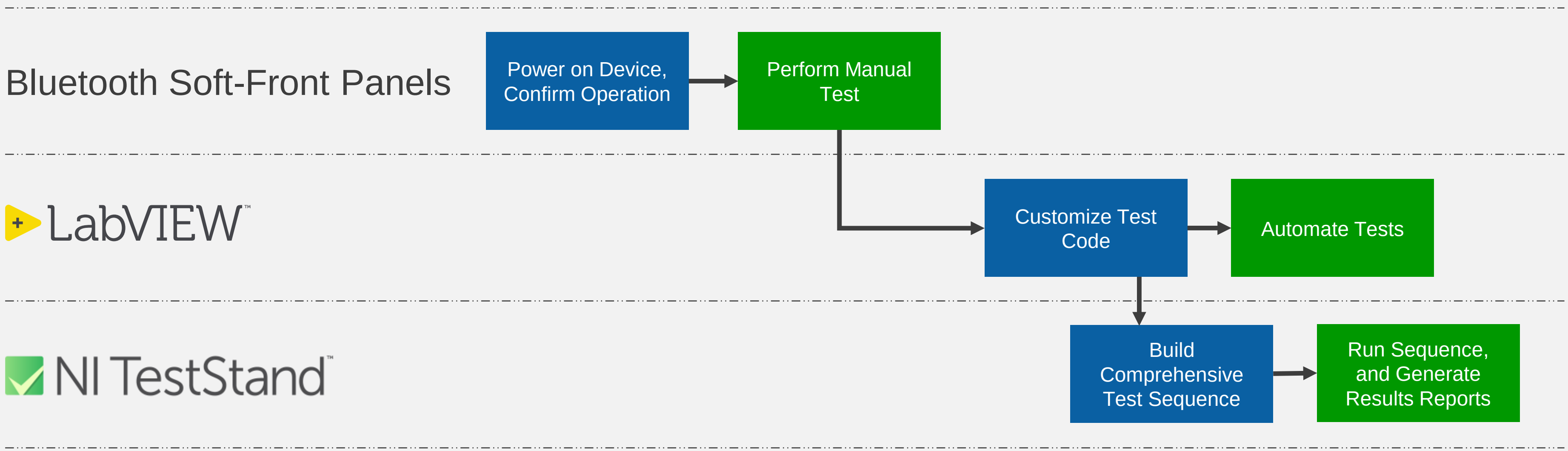
Standard	Packet Types in Bluetooth Toolkit	Data Rate	Modulation Scheme
Basic Rate (BR)	NULL, POLL, ID, FHS, DM1, DM3, DM5, DH1, DH3, DH5, HV1, HV2, HV3, DV, AUX1	1 Mbps	GFSK
Enhanced Data Rate (EDR)	2-EV3, 2-EV5, 2-DH1, 2-DH3, 2-DH5	2 Mbps	π /4–DQPSK
	3-EV3, 3-EV5, 3-DH1, 3-DH3, 3-DH5	3 Mbps	8-DPSK
Low Energy (LE)	LE-TP (Maximum payload length =37 bytes), LE-TP-EXT (Maximum payload length =255 bytes)	1 Mbps	GFSK
	LE-Enhanced	2 Mbps	GFSK
	LE-LR-125k	125 kbps	GFSK, Coded
	LE-LR-500k	500 kbps	GFSK, Coded

Specification Measurements in NI Bluetooth Toolkit

Measurement	BR	EDR	LE
Output Power (Toolkit includes payload bit decoding)	✔	✔	✔
Modulation Characteristics (df1, df2)	✔	N/A	✔
Carrier Frequency Offset and Drift (Frequency Error)	✔	N/A	✔
EDR Frequency Stability and ModAcc (Frequency Error, DEVM)	N/A	✔	N/A
TX Spectrum 20dB Bandwidth	✔	N/A	N/A
TX Spectrum Frequency Range	✔	N/A	N/A
TX Spectrum ACP	✔	N/A	N/A
EDR In-band Spurious Emission	N/A	✔	N/A
LE In-band emission	N/A	N/A	✔
BER	✔	✔	N/A
PER	N/A	N/A	✔
Interference tests	✔	✔	✔
Coexistence with other standards	✔	✔	✔

Characterizing and Validating a Bluetooth 5 Device

Workflow Demonstration



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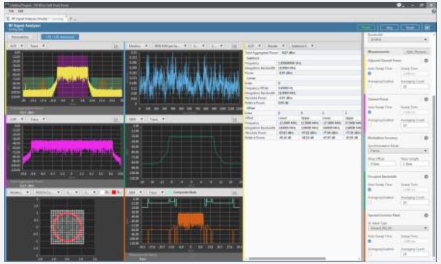
NI API

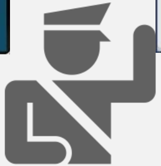


Automation Code

High BW
Direct Access

Instruments

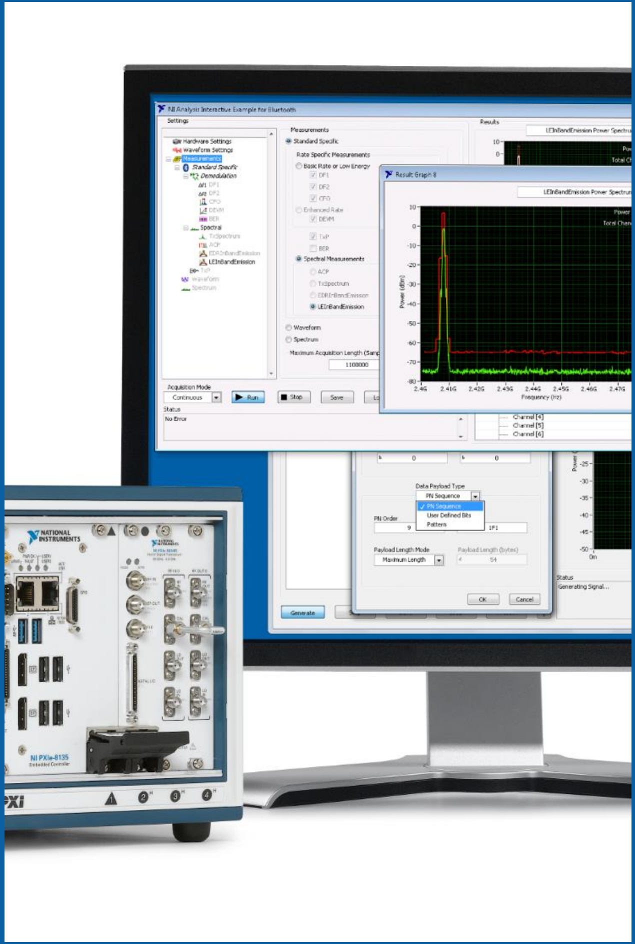
BOX



Automation Code

SCPI

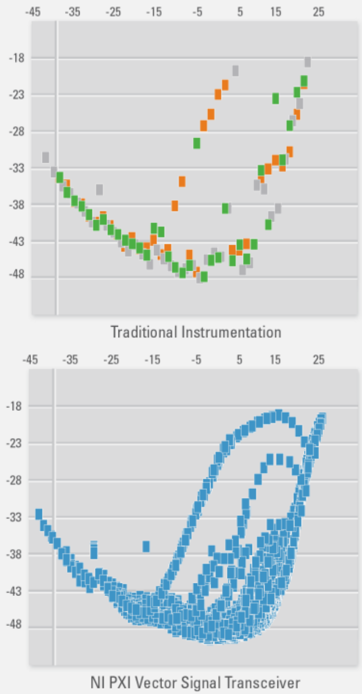
Instruments

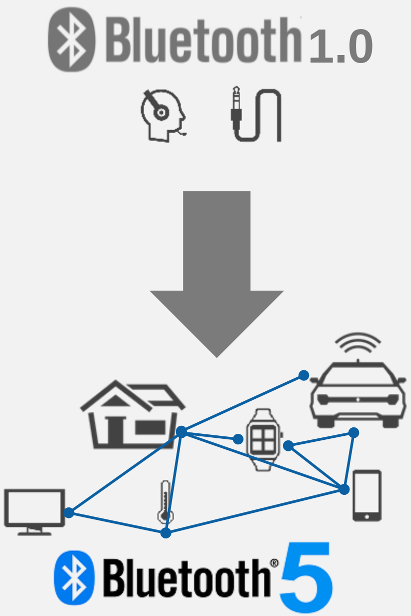


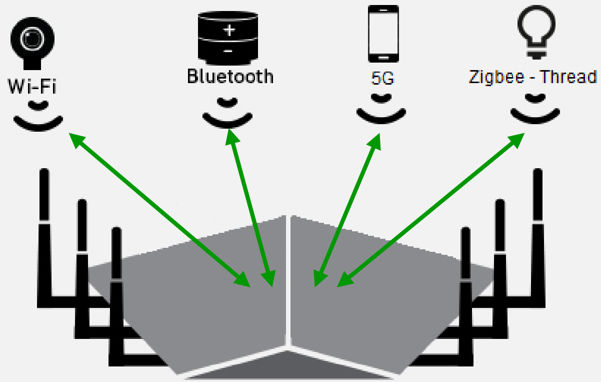
RFmx 3.0

- Bluetooth Generation and Analysis
  - Basic Rate, Enhanced Data Rate, and LE (up to 5.1)
  - 5.1 Direction Finding Packets
    - Supports analysis of direction finding packets (power, CTE frequency error; no angle calculation)
    - Support generation of direction find packets (no spatial channel emulation)
  - Analysis API and SFP
  - Generation SFP (API available in 18.0 Toolkit)
  - 5820 baseband support

Benefits of a Platform-based Test Approach







Increase design confidence | Keep pace with the latest specs | Validate standards coexistence

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