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# Volume-Optimized Functional Test

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Solution Brochure

# Volume-Optimized Functional Test

When scaling up production volume of electrical devices, one common approach is to distribute the test functionality across multiple stations. This pipelined approach can optimize cycle time and create flexibility improving efficiency for new product introductions. The challenge it brings is that engineers must scale down system cost and size to meet operational and financial expectations. Optimizing a system architecture for higher volume manufacturing using modular commercial-off-the-shelf (COTS) hardware and open productive software can meet test coverage requirements while simplifying development, deployment, and sustaining.

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# Test Station Architecture and Requirements

Traditional architectures for this use case come in two forms:

- **Filling a rack with box instruments, switches, and power supplies**—This solution is reasonable, but it has drawbacks in the large floor space requirement, high instrument and physical infrastructure costs, and long signal path, which increase the potential for errors.
- **Creating a custom instrumentation board**—This option lowers the price per station but only pays off for large deployments because of the initial design cost. Beyond costs, this solution also faces concerns with untested measurement architectures and higher maintenance costs as every design is unique and redesigns or component challenges must be funded by a single user.

Test engineers looking to optimize a solution for high-volume, lower-coverage electrical functional test, define requirements as:

- Meeting test coverage with stable reliable instrumentation
- Minimizing equipment cost and replication cost
- Minimizing footprint while preserving usability
- Integrating easily with industry standard software

These challenges are best addressed with the adoption of modular commercial-off-the-shelf (COTS) hardware and open, productive software. Modular hardware allows each system to be customized to meet specific application requirements, while the COTS model reduces development time and sustaining cost.

Choosing hardware which closely integrates (high-quality drivers and configuration tools) with industry standard software development and deployment tools, saves significant time and money throughout the development life cycle and therefore is a priority in most system specifications.

# NI Tool Architecture

This Test solution includes a complete set of products, including modular hardware, development software, and management applications to help you develop and operate functional test stations. NI and its global network of integration partners offer technical services to ensure customer success in designing, developing, and sustaining test stations.

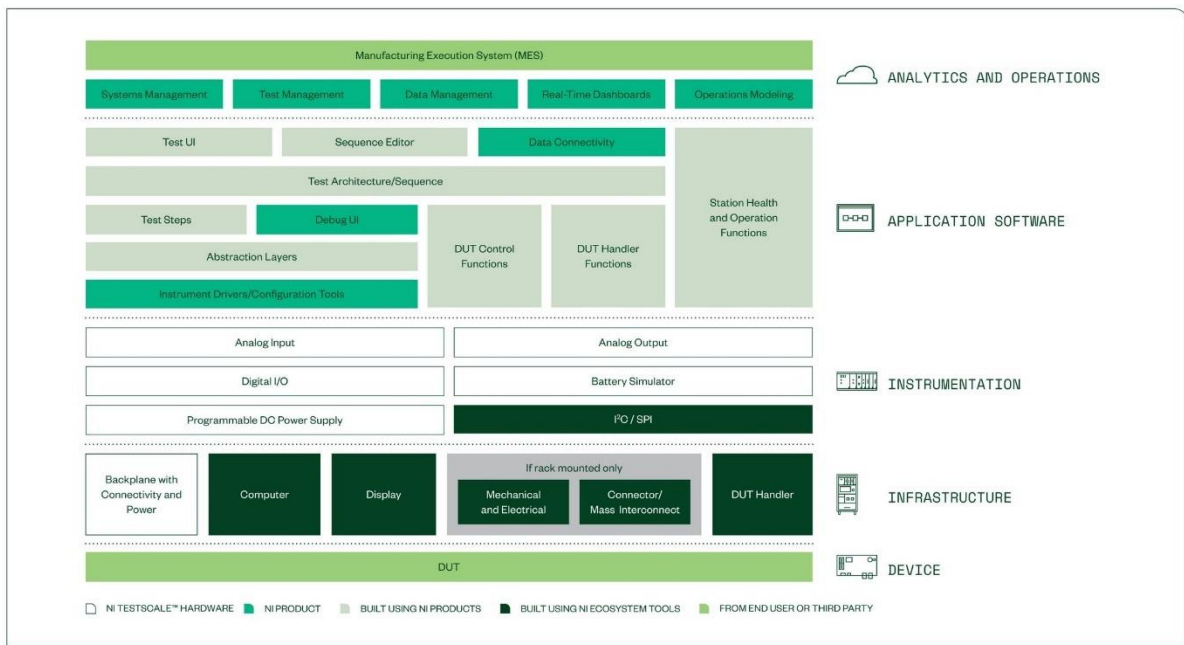


Figure 1: Architecture of hardware and software components in functional test station using NI TestScale

# Physical Architecture and Mounting Variants

The location of the instrumentation within the test station and in relation to the device under test (DUT) has the largest effect on cost, quality, and maintenance. Traditional rack-mounted architectures allow for easy access to instrumentation. However, in more stable deployment that will likely stay the same longer periods of time, a fixture mount is preferable.

For high accuracy and high test coverage [PXI](#) is the recommended instrumentation platform, this is too large to fit in most fixtures. But when test coverage requirements are less comprehensive and do not require synchronization, TestScale hardware mounted into the fixture can reduce floor space, shorten signal path, and significantly reduce costs because no rack, wiring, or mass-interconnect is required.

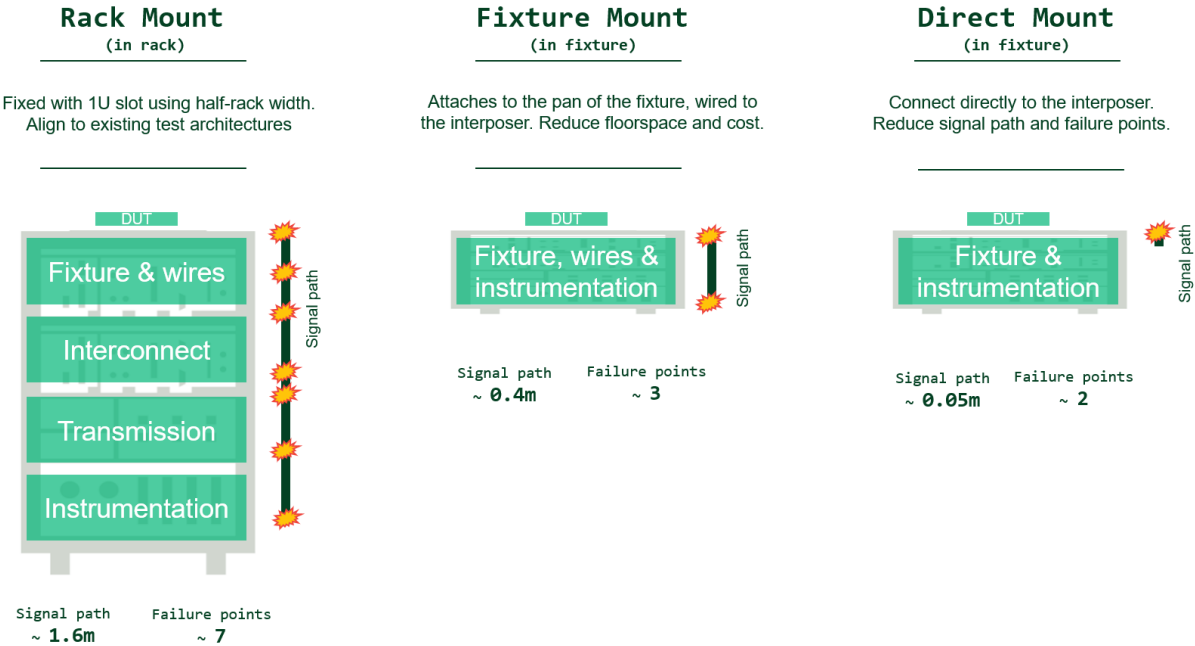


Figure 2: Monting architectures for NI TestScale hardware

In-fixture design test stations can reduce overall test station CapEx by up to 40 percent per station and reduce floor space usage by 50 percent.

# TestScale Instrumentation

NI TestScale hardware is a modular instrumentation platform that combines a lightweight USB backplane with slots for mix-and-match measurement modules. The backplanes can be daisy chained for high-channel-count applications, and the enclosure is optimized for in-fixture mounting.

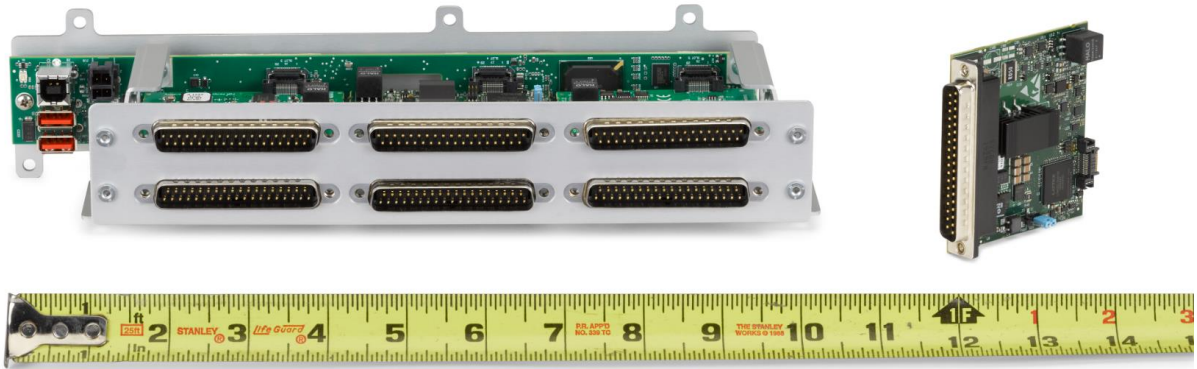


Figure 3: TestScale hardware: in-fixture fully populated chassis and separate module with tape marked in inches.

## Design features:

- Optimizes coverage with a flexible modular design and daisy chain, or star configuration of chassis.
- Facilitates easy, secure attachment to various sizes of fixture pans through its lightweight design with bottom, side, and top mounting options.
- Speeds fixture design with standard 37-pin connectors and a production-optimized form factor.

**Module Density:**

- 5 standard module slots
- 1 Controller module containing general-purpose I/O

**USB Hub:** One module slot supports a USB connection for DUT communication

**Input Power:**

- Backplane and I/O module powered through  $V_{SUP}$
- Programmable power supply powered through  $V_{SUP}$  or  $V_{AUX}$
- Input voltage range compatible with 24 V and 12 V systems

**Operating Range:**

- Maximum temperature of 55 °C
- Onboard temperature readback accessible through the NI-DAQmx API to enable thermal validation of deployment

## Software Compatibility

Software	Task
LabVIEW™	Create a module channel, create tasks, read NI-DAQmx measurements, and visualize/graph data.
TestStand™	Manage and create tests for specific measurements obtained from NI-DAQmx.
SystemLink™	Easily manage and view equipment status and test results in a user-friendly environment.
Python PyDAQmx	Interface between the NI-DAQmx driver and Python to use TestScale hardware.
C & C++	Create a module channel, create tasks, read NI-DAQmx measurements.

Figure 4: Software compatibility for TestScale hardware

## TestScale Measurement & Power Supply Modules

I/O Type	Channel Count	Details
Analog Input	32	<ul style="list-style-type: none"> <li>• <math>\pm 10</math> V (multiple ranges)</li> <li>• 250 kS/s</li> <li>• 16-bit</li> </ul>
Analog Output	4	<ul style="list-style-type: none"> <li>• <math>\pm 10</math> V (multiple ranges)</li> <li>• 100 kS/s/ch</li> <li>• 16-bit</li> </ul>
Digital I/O	32 (bidirectional)	<ul style="list-style-type: none"> <li>• 3.3 V and 5V TTL logic levels</li> <li>• 64 mA max output current</li> </ul>
Digital Output	32 (sinking output)	<ul style="list-style-type: none"> <li>• Up to 60 V logic level</li> <li>• Voltage level determined by <math>V_{AUX}</math> input on I/O connector</li> </ul>

Power Supply Output	6 V, 3 A, 18 W DC
Resolution	<ul style="list-style-type: none"> <li>• Programming: 2.5 mV, 1.5 mA</li> <li>• Measurement: 600 <math>\mu</math>V, 400 <math>\mu</math>A</li> </ul>
Accuracy	Programming and measurement: 0.2% + 10 mV, 0.4% + 15 mA
Remote Sense Capability	Readback with closed loop
Protection features	Overvoltage, overcurrent, and overtemperature notifications
Driver	NI DAQmx

This new hardware platform is currently under active development to increase I/O coverage, power supply specifications, and switching options. Contact NI for access to roadmap details.

Standardization initiatives with specific needs and high-volume deployments will be considered for custom engineering designs by NI and our partners. Contact NI for details.



# PXI Instrumentation

When test coverage breadth and depth increases or tight synchronization is required, the PXI platform is recommended. This is usually the case in multifunctional test stations for high quality products or non-distributed test line architectures. From wearable devices to headsets, industrial devices and life science, PXI instruments operate across tens of thousands of manufacturing lines worldwide. Chosen for their complete and accurate test coverage, with a flexible, modular architecture, you can control the instruments via PC either remotely or mounted alongside the modules in an ultrareliable [PXI chassis](#). The chassis also provides timing, triggering, and synchronization across a high-throughput backplane. You can rack-mount larger-format instruments alongside the PXI chassis.

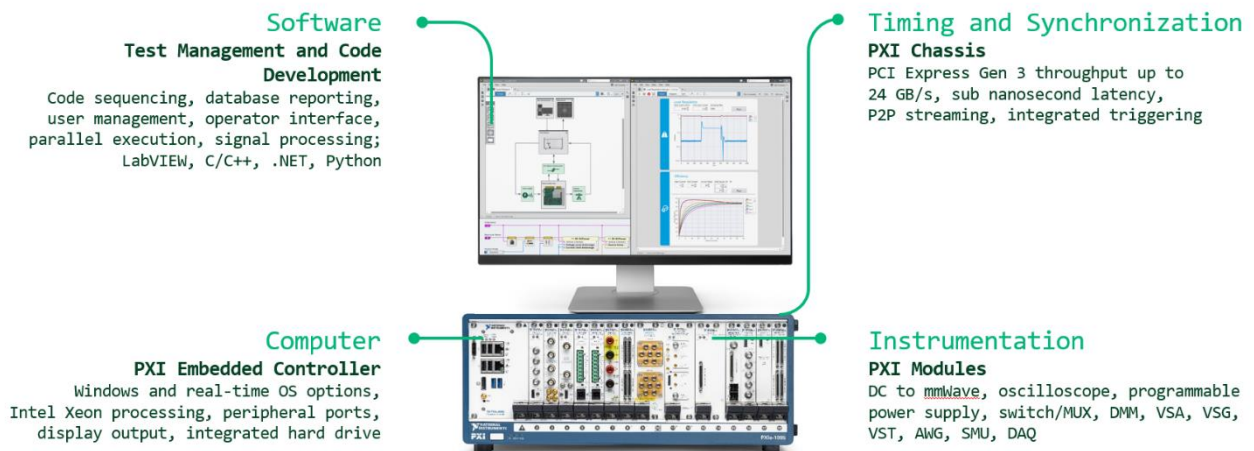


Figure 5. PXI Chassis Configuration

“Our solution uses LabVIEW and PXI modular instruments, including dynamic signal acquisition, to achieve our test system cost target, meet performance and quality requirements, and improve test throughput by 33 percent.”

Koh Chee Lit, Manufacturing Test, Sony EMCS

## PXI Instrumentation

NI offers more than 600 PXI modules, ranging from DC to mmWave. Because PXI is an open industry standard, nearly 1,500 products are available from more than 70 different instrument vendors. With standard processing and control functions designated to a controller, PXI instruments need contain only the actual instrumentation circuitry, achieving effective performance in a small footprint. Combined with a chassis and controller, PXI systems feature high-throughput data movement using PCI Express bus interfaces and sub nanosecond synchronization with integrated timing and triggering.



### Oscilloscopes

Sample at speeds of up to 12.5 GS/s with 5 GHz of analog bandwidth, featuring numerous triggering modes and deep onboard memory



### Digital Multimeters

Perform voltage (up to 1000 V), current (up to 3A), resistance, inductance, capacitance, and frequency/period measurements, as well as diode tests



### Power Supplies and Loads

Supply programmable DC power, with some modules including isolated channels, output disconnect functionality, and remote sense



### Waveform Generators

Generate standard functions including sine, square, triangle, and ramp as well as user-defined, arbitrary waveforms



### Switches (Matrix and MUX)

Feature a variety of relay types and row/column configurations to simplify automated test system wiring



### SMUs

Combine high-precision source and measure capability with high-channel-density, deterministic hardware sequencing, and NI SourceAdapt technology transient optimization



### Data Acquisition Modules

Provide a mix of analog I/O, digital I/O, counter/timer, and trigger functionality for measuring electrical or physical phenomena



### FPGA Data Acquisition

High channel count acquisition of digital signals with inline demodulation for efficient digital microphone communication.

# Instrumentation Hardware Services

Test station development and deployment is only half of the story. Best practices recommend that you consider station sustaining and maintenance from day one.

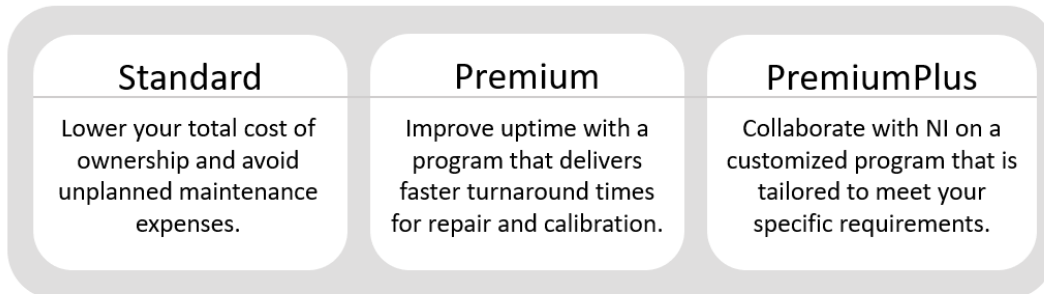


Figure 7. Instrumentation Hardware Service Levels

- **Budget Control**—Predict operational costs and avoid unforeseen maintenance expenses.
- **Minimize Downtime**—Get your systems back up and running within days, hours, or minutes with sparing programs, advance replacement services, and repair contracts.
- **Manage Life-Cycle Changes**—Manage technology refreshes and product obsolescence with roadmap consulting and life-cycle services programs encompassing one to twenty years.
- **Simplify Logistics**—Simplify hardware maintenance logistics and overhead with NI support.
- **Maintain Standards**—Utilize ISO 9001-traceable calibration and ISO/IEC 17025-accredited calibration services delivered onsite and through expedited shipping for confidence and convenience.
- **Speed Deployment**—Get up and running with custom installation that includes app software, custom documentation generation, individual logo/labeling, and system recovery images.
- **Quickly Troubleshoot**—Minimize development delays by consulting with experienced applications engineers based in more than 40 countries to meet your local needs in your local language.

“In the 25+ years I’ve been dealing with NI, I’ve always found their personnel to be uniformly bright, enthusiastic, and genuinely concerned with helping their customers succeed.”

Cary Long, Software Engineer

# Methodology Consulting Services

NI's expertise helps best-in-class companies develop test strategies to drive business insight. By connecting people, ideas, and technology, NI works with companies to craft plans that bring bold ideas to life.

## Value Assessment

Optimize your test strategy and evaluate business opportunities to deliver the highest return on investment (ROI). Leverage test insights from other industries, benchmarking against best-in-class companies, and financial modeling with your data to drive efficient, data-driven decisions.

## Professional Planning

Orchestrate change and mitigate risks by identifying enterprise-wide core gaps and inefficiencies across your siloed teams and functions. Transform your strategy into action with detailed plans that define clear roles and responsibilities, quantify project metrics, and allocate resources efficiently.

## Implementation Delivery

Utilize professional test services—including onboarding and technology-refresh—to accelerate your project. When development capacity is critical, free up resources by leveraging the expertise and program management of NI engineers and partners to deliver a complete solution that meets your schedule.

"Complexity of our products has grown exponentially, and the challenge of delivering a quality product within budget and schedule caused us to take a fresh look at our testing processes. It was natural to team with NI to benchmark our approaches against industry best practices. Together, we identified shifts in analysis and testing structures, integration, processes, and metrics, which we believe will provide sustained business impact."

—Jennifer Rumsey, CTO and VP, Cummins

"We're happy to report that, from the beginning of the project [to create a standard manufacturing test solution that supports hundreds of products across dozens of divisions] to today, new test solutions that are compliant to the standards can be delivered 40 percent cheaper than when we started the effort."

—Mark Keith, Chief Engineer, Honeywell Aerospace

# Application and Development Software

Because software development monopolizes the majority of test-project development labor, software tools and architecture choices significantly impact deployment schedules. Adopting a standard software approach across a team or organization increases both efficiency and proficiency, lowering the risk of missed deadlines, and improving test quality and reliability

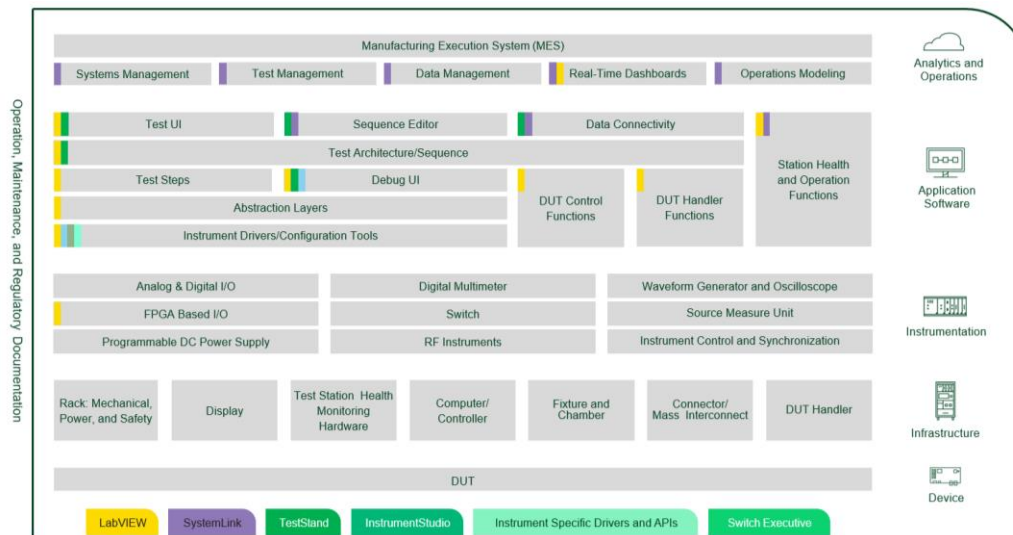


Figure 8. Test Station Software

Tens of thousands of engineers worldwide choose NI software for its rapid development environment, open architecture, and throughput-enhancing features, such as automatic parallel test-step execution. NI test software is the most complete engineering toolchain on the market, consisting of TestStand™, LabVIEW™, SystemLink™ software, InstrumentStudio™ software, and more.

NI test software is open and compatible with most other development languages, including C, C#, and Python, so that teams can reuse existing IP within test steps and sequences without sacrificing NI software platform-development benefits.

“The NI platform (especially LabVIEW and TestStand) has greatly increased our productivity and is a department standard. It probably saves us at least 40 hours on each project.”

Makenna Shaske, Test Development Engineer, Benchmark Electronics

## LabVIEW

LabVIEW offers a graphical programming approach that helps you visualize every aspect of your application, including hardware configuration, measurement data, and debugging. This visualization makes it simple to integrate measurement hardware from any vendor, represent complex logic on the diagram, develop data analysis algorithms, and design custom engineering user interfaces.

### Key Benefits:

- Reduce system setup with access to thousands of instrument drivers, example programs, and documentation to connect to virtually any instrument.
- Use hundreds of instrument-specific example code modules and included measurement libraries to reduce development time.
- Reuse existing code libraries from languages including C/C++/C#, .NET, Python, and MathWorks MATLAB® software.
- Quickly create professional user interfaces to visualize test outcomes.
- Build proficiency with extensive online and in-person training options for both new users and certified NI tool architects.

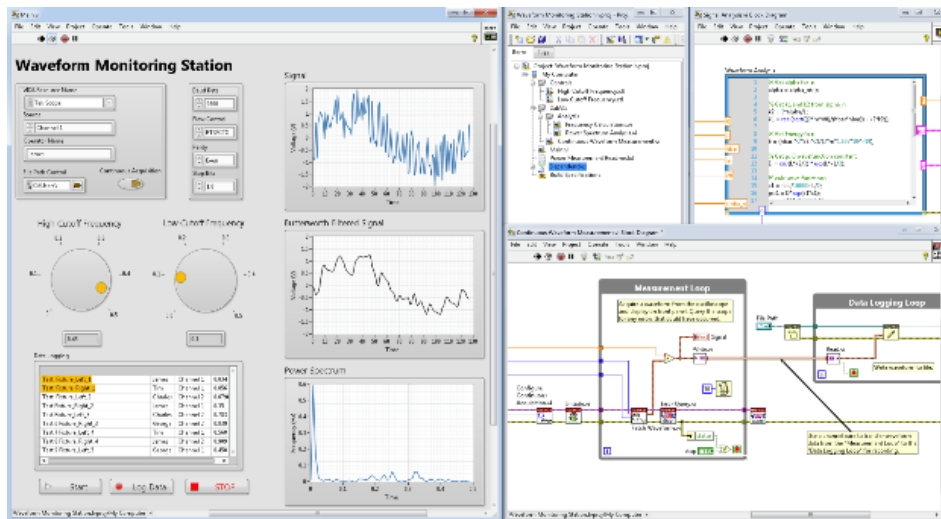


Figure 9. LabVIEW Software Interface

“Our team uses a common hardware platform across testing of numerous products. Reusability of common hardware configurations and utilization of common LabVIEW code simplifies development of new test systems.”

Brian Teschendorf, Software Engineer, Boston Scientific Corporation

## TestStand

TestStand ready-to-run test management software is designed to help you quickly develop and execute transaction processing system (TPS) software. You can extend TPS functionality by developing TestStand test sequences that integrate code modules written in a variety of programming languages, including G in LabVIEW, C/C++, .NET, and Python. TestStand also provides extensible plug-ins for reporting, database logging, and connectivity to other enterprise systems. You can deploy test systems to production with easy-to-use operator interfaces.

### Key Benefits:

- Customize test sequences to meet every requirement
- Automate saving and reporting test data
- Increase test throughput with parallel testing
- Efficiently replicate and deploy test systems
- Troubleshoot test systems with integrated debugging tools
- Customize user interfaces to meet testing needs

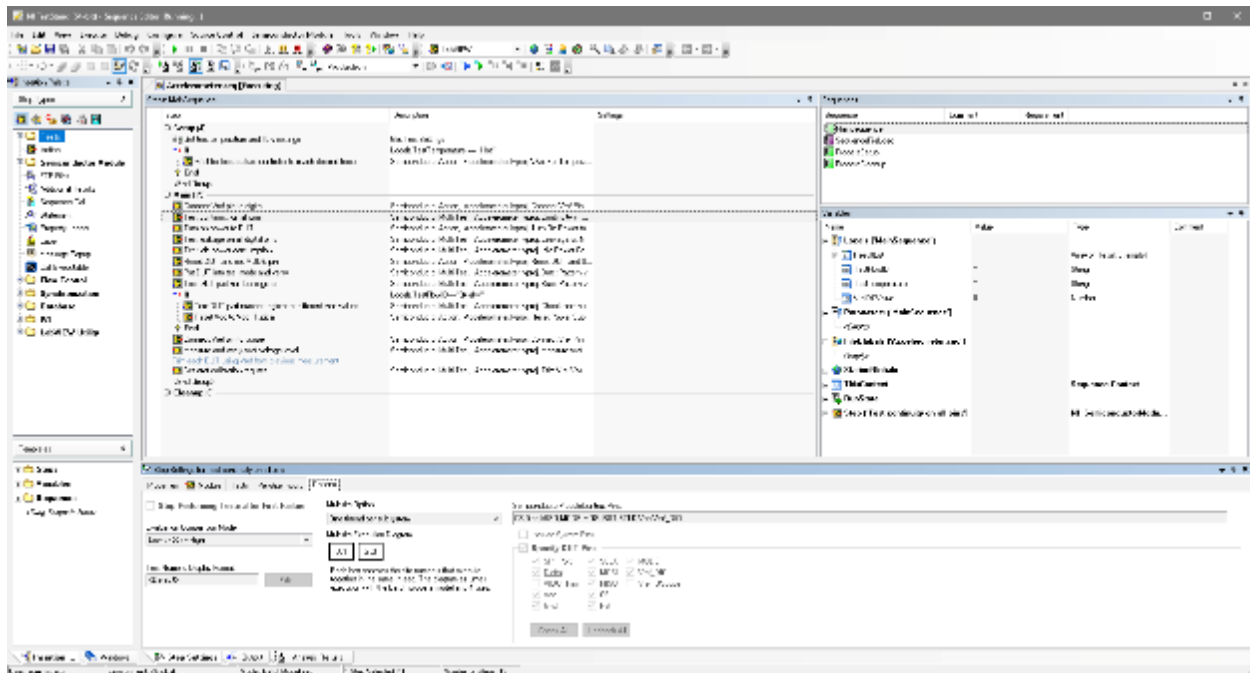


Figure 10. TestStand Software Interface

“TestStand has helped to decrease the time spent testing product and gets it to the market faster.”

Jared Smith, Test Engineer, Schneider Electric

## Instrument-Specific Drivers and APIs

NI measurement driver software includes best-in-class APIs that work with a variety of development options, such as LabVIEW, C, C#, Python, and others. To ensure long-term interoperability of our instruments, the driver APIs are the same for all past and current instruments. The driver software also provides access to help files, documentation, and dozens of ready-to-run shipping examples you can use as a starting point for your application.

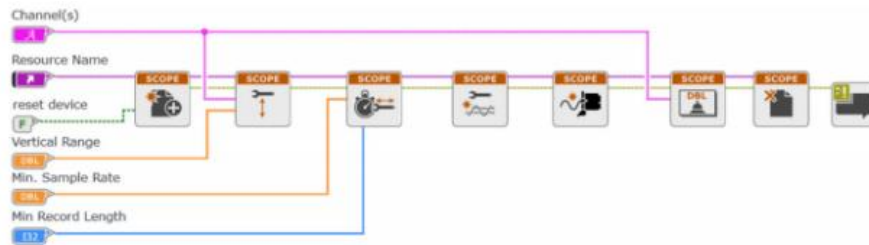


Figure 11. LabVIEW API for NI-SCOPE

```
// DAQmx analog voltage channel and timing parameters

DAQmxErrChk (DAQmxCreateTask("", &taskHandle));

DAQmxErrChk(DAQmxCreateAIVoltageChan(taskHandle, "Dev1/ai0", "", DAQmx_Val_Cfg_Default, -10.0, 10.0,
DAQmx_Val_Volts, NULL));

DAQmxErrChk(DAQmxCfgSampClkTiming(taskHandle, "", 10000.0, DAQmx_Val_Rising, DAQmx_Val_FiniteSamps, 1000));

// DAQmx Start Code

DAQmxErrChk(DAQmxStartTask(taskHandle));
// DAQmx Read Code

DAQmxErrChk(DAQmxReadAnalogF64(taskHandle, 1000, 10.0, DAQmx_Val_GroupByChannel, data, 1000, &read, NULL));
// Stop and clear task
```

Figure 12. C API for NI-DAQmx

```
import nscope
with nscope.Session("Dev1") as session:
    session.channels[0].configure_vertical(range=1.0, coupling=nscope.VerticalCoupling.AC)
    session.channels[1].configure_vertical(range=10.0, coupling=nscope.VerticalCoupling.DC)
    session.configure_horizontal_timing(min_sample_rate=50000000, min_num_pts=1000, ref_position=50.0,
    with session.initiate():
        waveforms = session.channels[0,1].fetch(num_records=5)
        for wfm in waveforms:
            print('Channel {0}, record {1} samples acquired: {2:}\n'.format(wfm.channel, wfm.record, len(wfm)))

    # Find all channel 1 records (Note channel name is always a string even if integers used in channel)
    chan1 = [wfm for wfm in waveforms if wfm.channel == '0']

    # Find all record number 3
    rec3 = [wfm for wfm in waveforms if wfm.record == 3]
```

Figure 13. NI-SCOPE Code Example Capture in Python



# Analytics and Operations Software

Test data visibility is increasingly in demand. Best-in-class companies realize that scrutinizing their functional test data provides real-time insight into changes in manufacturing yield, throughput, line health, and product quality.

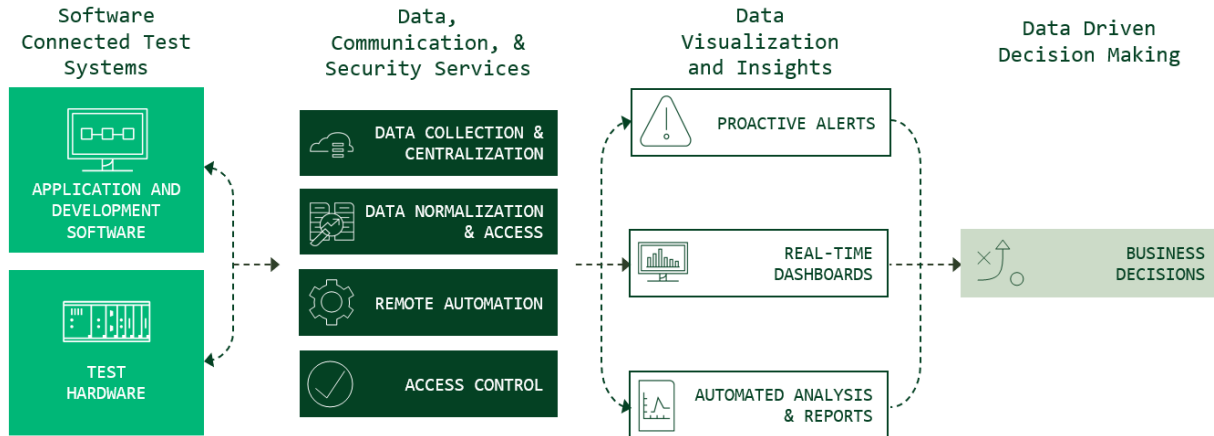


Figure 14. Architecture for effectively utilizing test data within manufacturing

Homegrown test data management solutions are prevalent. However, effectively developing and maintaining these solutions requires expertise in domains misaligned with test engineering workflows, including database connectivity, web services, IT systems, security, and visualization. Because these areas often do not contribute to key metrics by which test organizations are measured, they detract from the team’s success. To offset this, test organizations are moving towards a COTS systems and data management solution in which test engineers work within the areas that add the most business value.

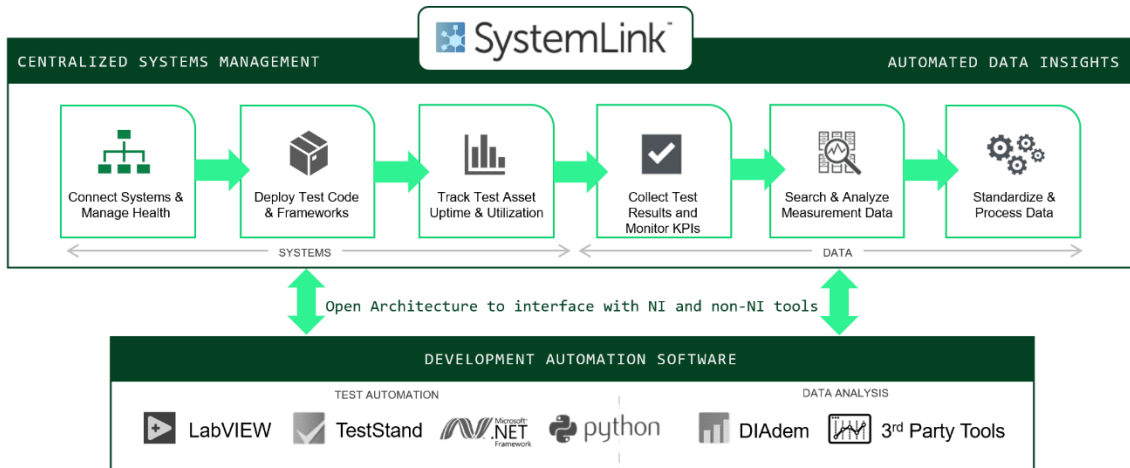


Figure 15. Architecture for Effectively Utilizing Test Data Using SystemLink

NI provides several tools and services to aid in the deployment of a data-centric infrastructure designed to improve manufacturing efficiency, product quality and customer satisfaction. SystemLink is the software product central to this; it provides easy data aggregation from individual stations and assets as well as analytics and visualization.

## SystemLink Software

SystemLink software eliminates the manual tasks related to keeping test systems current and healthy. From automating software updates to monitoring system health, SystemLink software delivers key information that improves situational awareness and test readiness. Leveraging an automation and connectivity framework, SystemLink software aggregates test and measurement data from all test systems into a centralized data repository. Users have ready access to asset utilization, calibration forecasts, and test-result history, trends, and production metrics data to make proactive decisions on capital expense, maintenance events, and test or product modifications.

SystemLink software is comprised of four modules—Software Configuration, Asset, Test, and TDM Data Finder. These modules provide application-specific capabilities that use the SystemLink server for data communication, transmission, and movement, as well as services for managing NI and non-NI instruments, software packages, alarms and notifications, and dashboards.

### Key Benefits:

- Centrally manage distribution software
- Optimize your software deployment process
- Perform remote device configuration and diagnostics
- Manage TPS performance health with alarms management, notifications, and calibration reporting
- Automatically prepare your data from multiple query and analysis sources
- Quickly access and search measurement data across TPSs
- Intelligently analyze files and generate reports automatically

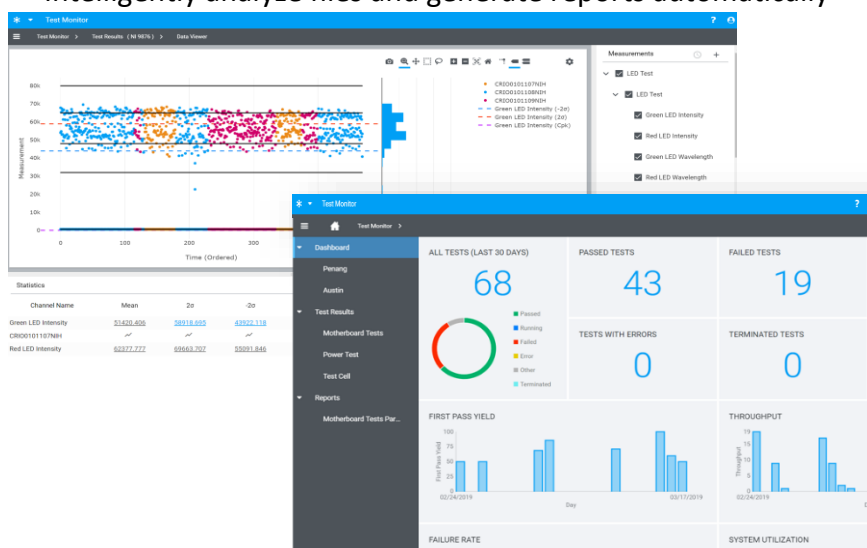


Figure 16: SystemLink dashboards

## Featured NI Partners

Best-in-class test engineering teams realize that there is seldom a simple question of in-house development versus outsourced development. Instead, they realize the complexity of deciding how to balance development teams to optimize for deployment schedule, bandwidth, domain-specific expertise, proficiency development, and available budget.

NI Partners are uniquely positioned to support your business with the service that it requires, including strategic design, system integration, specialist tools, software IP, and ongoing support. More than 1,000 NI Partners, each certified and vouched for by NI and positioned globally, stand ready to consult with you on projects and provide complete solutions based on NI's productive software and modular hardware.

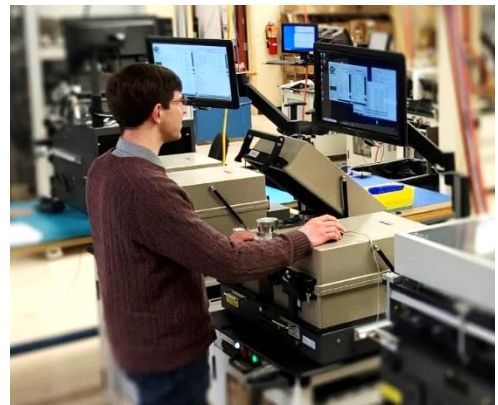
### Partnering in Your Success

- **Integrators**—These integration companies offer certified production test specialists to help reduce development time and cost by providing expertise and complete solutions.
- **Consultants**—These hourly consultants help mitigate risk and shorten design cycles through software architecture design, code review, and individual or team training.
- **Tools and Apps**—Build specialist IP into your solution to add functionality or reduce development time. The LabVIEW Tools Network offers hundreds of add-ons, toolkits, and reference applications compatible with NI and industry platforms.

## Featured NI Partner: Circuit Check

Circuit Check is a leading provider of automated test systems and interfacing solutions (test fixtures and interface test adapters) for complex industrial, medical, automotive, military/aerospace, and computer networking industry electronic products. Circuit Check specializes in rapidly designing and deploying complex systems, including, automation, vision, and user-interface testing. Design staff includes electrical, software, and mechanical engineers. Each project has a dedicated project manager to ensure successful test system completion throughout the United States, Canada, Mexico, Europe, Malaysia, and China.

- Reduce project delivery risk with a proven record in mission-critical projects with turnkey solutions built to the highest quality and reliability.
- Augment your experience and knowledge, not just bandwidth: In-house design teams deliver successful, well-thought-out solutions that work the first time.
- Reduce the cost of test by optimizing test measurement design through design for testability (DFT) consulting, requirements-specification development, and building best practices.
- Scale efficiently when deploying large numbers of stations distributed across multiple sites.
- Receive support throughout your test station life cycle, from design to development, deployment, start-up, and sustainability.



Circuit Check stands out as a system integrator by providing a personal consultative service to every test project—big or small. This service includes:

- Dedicated project managers to ensure successful test system completion. Communicate with one point of contact through the entire project.
- A full test system documentation package (including a bill of material, system overview, hardware setup, operator manual electrical schematic, and test results).
- A customer documentation review and update (including customer mechanical and electrical design documents for testability).

To learn more, visit [circuitcheck.com](http://circuitcheck.com) or call (763) 694-4100.



## Featured NI Partner: Booster Electronics Technology

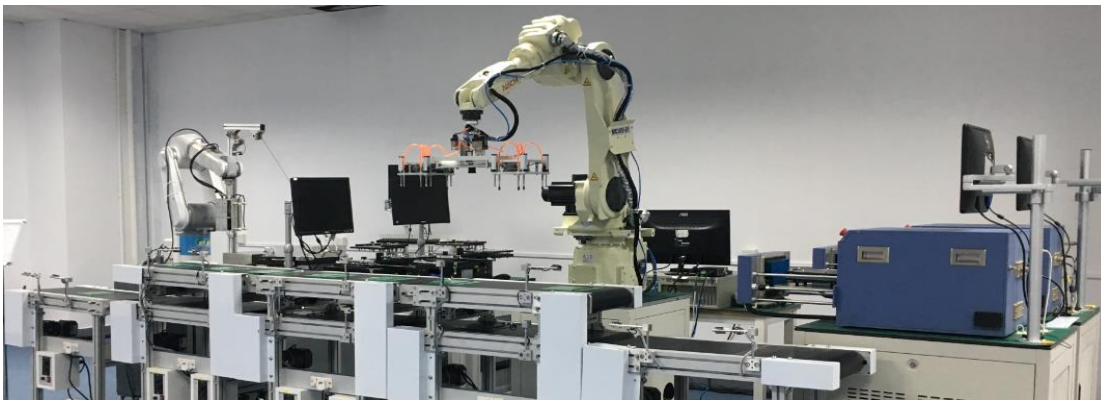
Booster Electronics Technology is a professional and dedicated manufacturing test development and test automation solutions provider based in China with a worldwide service and support network.

- Scale to any size project with more than 110 test development and design engineers who cover most of the product catalog test development, design knowledge base, and required capabilities.
- Minimize costs and lead times with in-house high-quality fixture design and fabrication, including RF and audio/acoustic chamber expertise.
- Receive support for your entire test line—from DFT and early-stage test-strategy consultation, through development, to sustaining.
- Take advantage of timely worldwide service and support.



Figure 26. Test Station with Fixtures

General Electric named Booster one of only three WW Certified Test Development Systems Integrators based on quality of service and international presence.



Visit [boostertech.cn/m/en/](http://boostertech.cn/m/en/) to learn more.

Email: [andy.zhang@bcd-autotest.com](mailto:andy.zhang@bcd-autotest.com)

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Mobile: +86 18688150629



## Featured NI Partner: Avera

Avera is a premier test-solutions provider for technology innovators worldwide. As an NI Partner, Avera's test expertise spreads from consumer electronics, telecom, and life sciences to aerospace, defense, and automotive.

With more than 20 years in business, Avera has a proven record in helping clients accelerate product development, reduce manufacturing costs, achieve uncompromising test coverage, and solve supply-chain issues.



Undertake projects of any size with the support of more than 240 globally located engineers and software experts—including more than 140 NI-certified architects, developers, and instructors.

- Build with confidence assured by Avera's track record of more than 6,000 successful projects.
- Solve complex problems with accredited specialty product support for NI tools, including RF/wireless and SystemLink software.
- Meet production volume requirements with mechanical design that scales from simple manual fixtures to fully automated inline installations.

Learn more at [insight.avera.com/request-for-information-avera](https://insight.avera.com/request-for-information-avera).





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## NI Services and Support

NI offers a variety of solution integration options customized to your application-specific requirements. You can use your own internal integration teams for full system control or leverage the expertise of our worldwide network of Alliance Partners to obtain a turnkey system.

Contact your account manager or call or email us to learn more about how NI can help you increase product quality and accelerate timelines at (888) 280-7645 or [info@ni.com](mailto:info@ni.com)

## NI Services and Support



Consulting and Integration



Turnkey Solution Delivery



Repair and Calibration



Global Support



Prototype and Feasibility



Training and Certification

[ni.com](http://ni.com)

