NI Tools for Hardware-in-the-Loop Testing

Overview

The rapid pace of technology is bringing about changing test requirements that modern hardware-in-the-loop (HIL) test systems must be flexible and customizable enough to meet. Embedded software testers need HIL systems that can keep pace as technologies like advanced driver assistance systems (ADAS), autonomous vehicles, fly-by-wire, and fuel economy techniques make their way into production. Because a one-size-fits-all test solution is now often quickly outdated, NI test systems are built on open, industry-standard platforms that can evolve as test requirements do. NI HIL systems are made up of off-the-shelf components that can fit together into either a turnkey system that you can quickly deploy into your application or a do-it-yourself system that delivers the ultimate in application flexibility and cost optimization.

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System Overview

With NI's open, flexible HIL solutions, you can make customizations to fit your specific needs. Using a modular architecture, easily upgrade the platform with added functionality to future proof your test systems and meet the requirements of the most demanding embedded software test applications. Compared to competitors, NI's performance capabilities make it the best option for testing innovative control systems.

Figure 1 below shows how the various hardware and software components are assembled into an HIL system. The system includes software for data manager and test automation in addition to the HIL test execution and interface. Below the software are two different hardware platforms for modular I/O and a third that is used for application-specific switching, loads, and signal conditioning. This last one is then connected to the device under test (DUT) through various connectivity options, depending on the device.

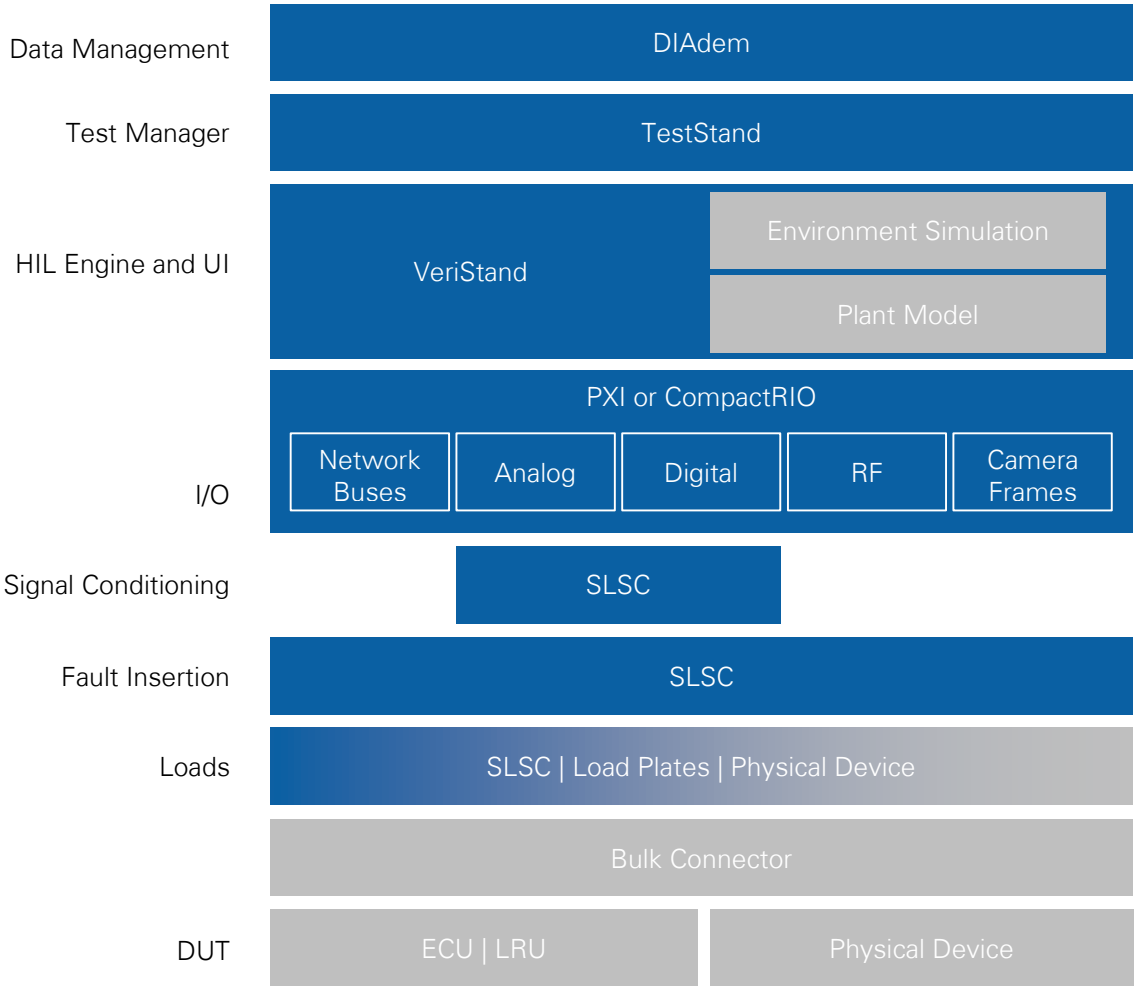

Figure 1. An HIL system built on NI components offers the ultimate in flexibility because it is built on modular, off-the-shelf components.

Turnkey HIL Simulators

For a turnkey system that is ready to deploy but still built to fit your exact application requirements, you can look to NI HIL specialty partners around the globe who build and deliver HIL Simulators. These partners have extensive experience in integrating NI hardware and software as well as the vertical

application of HIL in automotive, aerospace, and other industries. These systems are built to exact specifications and architectures defined by NI and on NI components to ensure a consistent quality and user experience anywhere in the world.

With industry-leading customizability, HIL Simulators help you easily adapt to changing test requirements across a wide variety of application areas, including ASAS, electrification, and advanced sensor integration with cameras, radar, and ultrasonics. Additionally, these simulators provide easier test system commissioning and system integration so you can find more engine control unit (ECU) defects faster.

NI HIL Simulators are built to integrate into your existing workflow while still giving you the flexibility to adapt to future requirements by including features like the following:

- Model integration from more than 20 simulation environments, including The MathWorks, Inc. Simulink® software
- Fault injection for networks and electrical systems
- Electrical load integration
- RF and camera I/O to keep pace with the latest industry trends
- User-programmable FPGA-based I/O for advanced models
- Flexible bus support including CAN, LIN, FlexRay, ARINC, AFDX, and MIL-STD-1553
- Unlimited expansion capabilities through multiple system connections

Figure 2. HIL Simulators are turnkey HIL systems built on NI's open platforms and delivered by a vetted NI HIL specialty partner with extensive industry experience.

Software

VeriStand

VeriStand is a software environment for configuring real-time test and HIL applications. Out of the box, VeriStand can help you construct a multicore-ready real-time engine to execute tasks such as real-time stimulus generation, data acquisition for high-speed and conditioned measurements, and calculated channels and custom channel scaling.

VeriStand can also import control algorithms, simulation models, and other tasks from both LabVIEW software and third-party environments. You can monitor and interact with these tasks using a run-time editable user interface that includes tools for value forcing, alarm monitoring, I/O calibration, and stimulus

profile editing. Although you don't need programming knowledge to use VeriStand, you can customize and extend it with a variety of software environments such as LabVIEW, ANSI C/C++, ASAM XIL, and others for modeling and programming.

VeriStand is architected to have a real-time engine that runs independently from the user interface to ensure the determinism of the system you are running.

Figure 3. VeriStand is NI's HIL testing software and offers model execution, stimulus generation, data acquisition, customizable UI, and logging among other features.

Extending VeriStand Capabilities

VeriStand has an open framework that you can use to add specific functionality with LabVIEW. Create add-ons to add support for specific hardware or even create new software functionality that is nonnative. Both NI Alliance Partners and NI have already deployed a number of add-ons that you can download from the community.

VeriStand also provides a .NET-based API that you can use to create custom interfaces for VeriStand or to implement automation of the configuration and/or operation of VeriStand applications. For example, you can use the API library to create a custom configuration window that limits the changes a user can make to a VeriStand application or to simplify the configuration process by making it possible to specify the application parameters in a spreadsheet. Or you could automate the operation of a VeriStand application or create a completely custom run-time interface. These .NET-based APIs can be used by LabVIEW, TestStand, and a variety of other environments that can use .NET interfaces like Python.

TestStand

TestStand is a ready-to-run test management software that is designed to help you develop automated test and validation systems faster. You can use TestStand to develop, execute, and deploy test system software. In addition, you can develop test sequences that integrate code modules written in any test programming language. Sequences also specify execution flow, reporting, database logging, and connectivity to other enterprise systems.

You can use TestStand to automate an HIL test application by calling the VeriStand .NET-based execution API. TestStand can also manage hardware and software from multiple platforms in a single TestStand sequence. For example, it can automate VeriStand real-time sequences running on an NI PXI real-time

controller, while simultaneously controlling a third-party instrument using its native IVI driver support. After you run your test, you can log test result information in a customizable report or database automatically. Additionally, systems written in TestStand integrate with existing source code control, requirements management, and data management systems.

You can also integrate TestStand into third-party test management and test generation software platforms. For example, you can use TestStand with MaTeLo from All4Tec to generate automated tests based on your application requirements. Whether you would like to use TestWeaver with VeriStand or MaTeLo with TestStand, you can create a test system to not only automate tests but also automatically generate unit tests to make your ECU fail. This helps you focus on testing embedded software thoroughly instead of writing new test scripts from scratch.

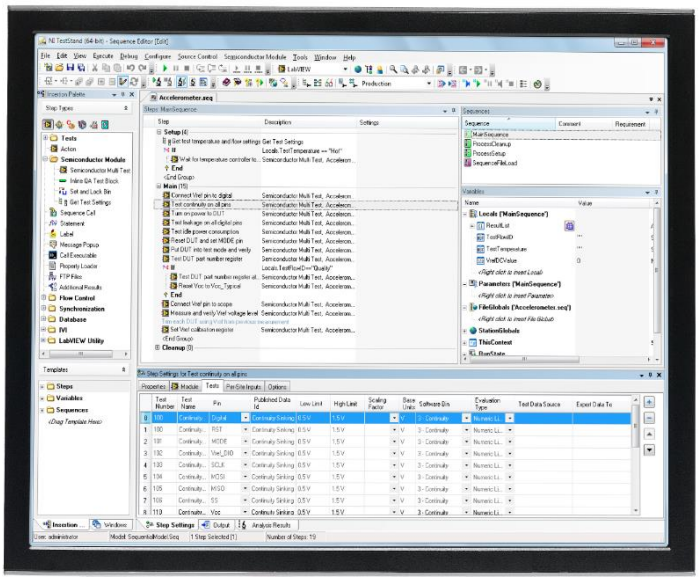

Figure 3. TestStand is NI's test automation software and can be used to automate VeriStand for faster and more efficient testing.

DIAdem

Successful engineering enterprises share characteristics such as consistent data logging, analysis, and effective data management. This is especially true of HIL test applications where design and test teams must collaborate to ensure embedded software and mechanical system product quality. Implementing a standard, automated means of data analysis and report generation helps you view data in a consistent way, improves test efficiency, and makes data much easier to find and interpret. You can use VeriStand with DIAdem to quickly and easily log data, perform post-processing, and generate reports—all from the VeriStand UI tools.

DIAdem is a single software tool that you can use to quickly locate, load, visualize, analyze, and report measurement data collected during data acquisition and/or generated during simulations. It is designed to help you quickly access, process, and report on large volumes of scattered data in multiple custom formats to make informed decisions.

Figure 4. DIAdem is industry-leading data mining, analysis, visualization, and reporting software.

Hardware

PXI

PXI is a rugged PC-based platform for measurement and automation systems. PXI combines PCI electrical-bus features with the modular, Eurocard packaging of CompactPCI and then adds specialized synchronization buses and key software features. PXI is both a high-performance and low-cost deployment platform for a wide range of applications that includes HIL test. Developed in 1997 and launched in 1998, PXI is an open industry standard governed by the PXI Systems Alliance (PXISA), a group of more than 70 companies chartered to promote the PXI standard, ensure interoperability, and maintain the PXI specification.

A major benefit of the PXI platform for HIL is the wide range of I/O options that can be integrated into the test system. As the automotive industry evolves to incorporate new technologies, such as automotive radar, cameras with onboard image processing, V2X, and real-time GNSS position tracking, HIL systems must also evolve to verify the safe operation of these technologies. With available vision, high-performance FPGAs, and RF modules that meet the needs of the latest automotive standards, such as 77-82 GHz radar, the PXI platform is uniquely positioned to meet the demands of these new test requirements.

In most cases, PXI is the best solution for HIL testing. It provides high channel count and density, the broadest availability of I/O, and the highest processing capability available. In addition to high-performance hardware, PXI also offers the best software experience for HIL testing, as it supports the most modeling environments and seamless DAQ hardware support.

Figure 5. PXI is a high-performance, industry-standard I/O platform with built-in real-time processors, user-accessible FPGAs, and modular I/O including network buses, analog and digital I/O, and camera and radar I/O and simulation capabilities.

CompactRIO

CompactRIO is a rugged hardware design in a compact form factor that is ideal for most harsh environments as well as lab settings that require a small physical footprint. Although typically providing lower computational performance than PXI, CompactRIO offers high-performance processing and heterogeneous computing elements including ARM-based Xilinx Zynq SoCs as well as quad-core Intel Atom processors and Xilinx Kintex-7 FPGAs. CompactRIO also includes signals with measurement-specific signal conditioning, built-in isolation, and industrial I/O.

CompactRIO is an ideal fit for benchtop HIL systems. It doesn't have as many I/O options as PXI, but the compact form factor and lower price make it a great choice for unit testing of ECUs that require integrated processing and FPGA performance such as ECU testing.

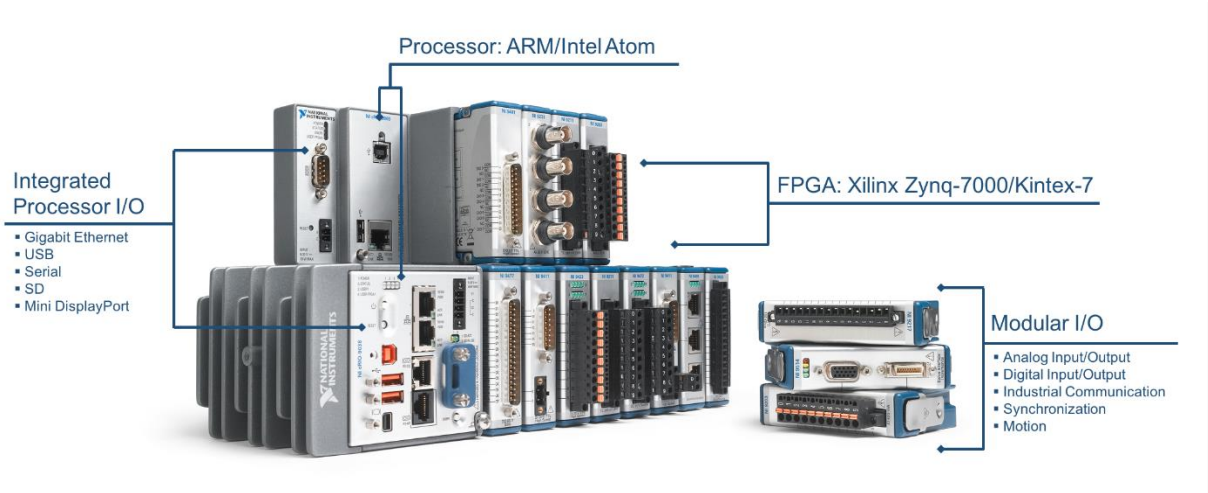

Figure 6. CompactRIO is a smaller, modular I/O platform well suited to benchtop HIL testing. It also comes with built-in real-time processing, user-accessible FPGAs, and modular I/O.

SLSC

SLSC extends PXI and CompactRIO measurement hardware with high-power relays for signal switching, power loads, and additional inline signal conditioning capability. The system consists of a chassis with built-in active cooling that can host 12 modules. SLSC plug-in modules can operate in the chassis in three different modes: standalone, pass through, or cascaded. You can use cascaded mode to implement functionality like signal fault insertion. You can select from a variety of NI and third-party modules or create your own based on a detailed hardware and software development kit from NI.

SLSC is designed to simplify overall system integration, reducing system point-to-point wiring by accumulating signals and using standard cables. Each SLSC chassis consists of an SLSC digital bus that is used to discover, configure, and set parameters on the individual modules. Signals pass through SLSC modules either from the front connector or the rear expansion connector. You have the flexibility to design your own secondary backplanes to reduce system wiring using a custom application-specific backplane integrating the signal flow.

Figure 7. SLSC is an open architecture for standardizing the switches, loads, and signal conditioning that are often custom for each HIL application.

Next Steps

Learn more about:

- Turnkey HIL Simulators
- VeriStand
- TestStand
- DIAdem
- PXI
- CompactRIO