Instrumentation newsletter™

Technical News from National Instruments

Fourth Quarter 2001

Intelligent, Networked Systems with NI LabVIEW™ Real-Time

National Instruments introduces two hardware devices for the FieldPoint™ distributed I/O and PXI/CompactPCI™ platforms to run LabVIEW Real-Time. Both the FieldPoint modules and PXI real-time controllers offer lower-cost, compact, industrial systems with better vibration, temperature, and size specifications than previous devices running LabVIEW Real-Time software.

With the ability to embed, network, and run LabVIEW on the FP-20xx modules and PXI-8140 RT controllers, devices substantially smaller than a PC, you can now create reliable, real-time, integrated measurement and control solutions in areas including design and validation, manufacturing test, process monitoring and control, and machine monitoring and control.

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PC-Based Spectral Analysis – Accurate and Efficient

By combining the PC with National Instruments software and hardware, you can now perform spectral analysis with higher channel counts and more bandwidth than ever. NI offers both dynamic signal acquisition (DSA) boards and high-speed digitizers that you can use to solve spectral analysis applications.

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NI Investment in PCI Meets Current and Future I/O Needs

During the past decade, the PCI electrical bus has flourished into a highly successful, general-purpose I/O interconnect standard. Not only is it the dominant electrical architecture on which you build modern desktop PCs and workstations today, but its architecture is also common in a wide variety of additional platforms used in measurement and automation applications, including Cardbus, PC-104+, and PXI/CompactPCI.

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NATIONAL INSTRUMENTS™

Here's What You Missed...

- Creating flexible, scalable PC-based data logging solutions
- Bringing order analysis to sound and vibration with the NI Order Analysis Toolset
- Learning about the world-class technical support features, such as Request Support, at ni.com/support

...If You Missed the Last Issue.

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Windows XP – A New Windows Experience

Some claim that Windows XP is the most ambitious operating system released by Microsoft since Windows 95. The final version of this Microsoft operating system was scheduled to be available in retail stores on October 25, 2001. As of the printing of this *Instrumentation Newsletter* issue, it was already possible to order computers with Windows XP installed. National Instruments worked with early development/beta versions of Windows XP to not only ensure operations of our current products, but also look for ways to maximize new features and capabilities to meet your measurement and automation needs.

Strengthened Stability and Networking

The changes in Windows XP are apparent from the moment you start up the system and see the Welcome screen. The user interface is dramatically updated, and Microsoft claims this makes XP much easier to use. While we may all appreciate improvements to the interface, some of the more fundamental changes to the operating system may have a larger impact on the work of engineers and scientists. The foundation of Windows XP is based on Windows 2000 code, which means greater stability for the environment. In addition, networking and connectivity is improved and strengthened. The stability and networking features alone should bring benefits to measurement and automation systems.

NI Supports Your Application

Realizing that the vast majority of measurement and automation systems run on Windows-based PCs, we want to make sure that we help you understand how a new version of Windows affects systems you have today, as well as systems you plan to develop tomorrow. This service includes providing information on new features of the operating system. Rather than simply relaying those features from a Microsoft perspective, we want to explain the features in terms of what matters to engineers and scientists. That is why you can find information about Windows XP in this publication, at seminars, and on our Web site. If you have questions about the use of Windows XP in your application, give us a call, and we can discuss the details.

Details on ni.com™

We also realize that you may place existing systems on new PCs with Windows XP installed. We have tested our products with Windows XP for many months. Through our Web site, we are providing detailed technical information and updates on support of our products with Windows XP. NI has a long track record of supporting our users throughout the history of PC operating systems, from DOS to Windows XP.

PCs are clearly the center of today's measurement and automation systems. NI remains committed to providing you with the software and hardware that fully leverage the power of the PC for measurement and automation, and Windows XP is a new step in what we like to call the Measurement Revolution.■

John Graff, VP Marketing

For details on NI support of Windows XP, visit ni.com/info and enter nsi1406.

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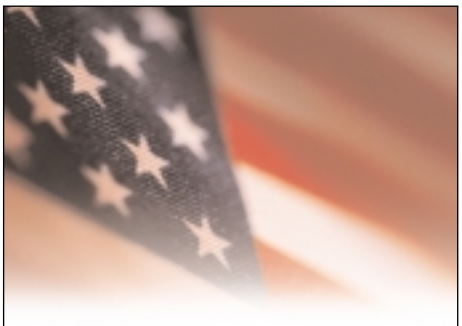


National Instruments would like to express our deepest sympathy to those tragically affected by the events of September 11, 2001. The events have saddened us all and brought us together.

May we, as a worldwide community, find peace in the months to come.■

NI Automates Biotechnology Measurements

Biotechnology innovations over the last century have increased life expectancy considerably. The recent genomics revolution has resulted in a new class of medicines that could further extend human life and change the health-care industry. The automation of measurements is pivotal in the rapid discovery of these new medicines. You can replace tedious, time-consuming experiments with PC-based measurement and automation devices controlled by NI LabVIEW, thus increasing throughput. You can use these PC-based software and hardware products in a wide range of biotechnology applications, including personal therapy guidance technology, human resistance to drug therapy, rapid development of new biomaterials, and identification of specific protein functions.

Reducing Test Time

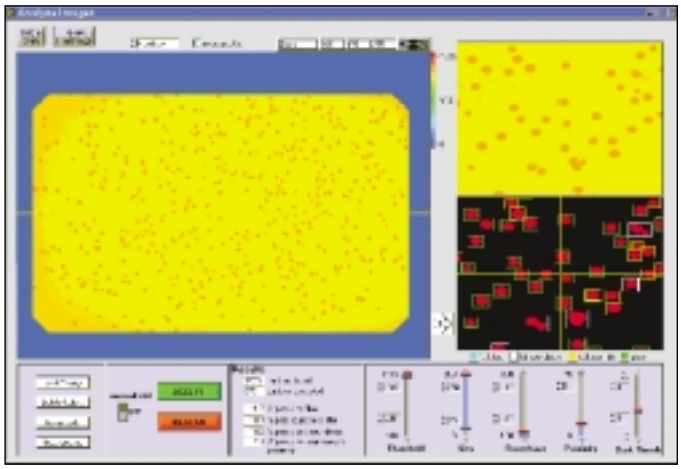
National Instruments products are helping biotechnology companies create revolutionary methods of identifying therapeutically relevant targets and enabling the rapid testing of compounds for their potential use as new medicines. You can generate assays to rapidly measure target activity in living cells. The key benefit of automation is the ability to accelerate the process of drug discovery by developing many assays in a relatively short period of time.

Vision, Motion, and Measurements

You can use NI vision products for test-tube location, culture analysis, and fluorescence-imaging analysis. Sophisticated algorithms for particle analysis and pattern matching can locate and characterize all the relevant items in a given sample. Color matching algorithms can identify the various color responses of compounds as they react to reagents. NI data acquisition (DAQ) products make a variety of “wet" or chemical measurements. Using special sensors, you can take measurements such as pH and culture-growth rate.

Furthermore, by using the high-speed real-time system integration (RTSI™) bus, you can synchronize DAQ measurements with motion control or image acquisition to increase throughput and accuracy. NI motion control products automate these measurement processes by moving x-y stages or robotic arms, which is important to process the thousands of assays required for any clinical test. Automation is also important for processes involving biochips and micro-arrays.

LabVIEW is the software that powers this automation. It integrates all motion control, vision, and measurements under one application development platform, facilitating interoperability among the many devices that comprise a biotechnology machine. You benefit by decreasing time-to-market and creating biotechnology machines that have faster throughput.



GeneMachines uses LabVIEW as the “glue” that integrates imaging, measurements, and motion control tests into a test system.

Automated Solutions

The Plaque and Colony Picker from GeneMachines provides an automated solution for the genomics and proteomics community using NI LabVIEW, data acquisition, and vision products. The GeneMachines picker provides high-throughput picking of bacterial colonies via motion control for DNA sample preparation and cell screening. The NI vision component characterizes each of the colonies’ size, color, and number to selectively pick and evaluate the samples, while the data acquisition component helps monitor and control the fluid flow.

Molecular Devices Chemiluminescence Imaging Plate Reader (CLIPR) system, which uses NI motion control products, is a high-throughput screening system for testing individual drug compounds. You can use NI motion products to carefully place these drug compounds into tiny, individualized wells. The system finds drug “hits" by measuring luminescence with a vision system to test how certain drug compounds react. The result of this reaction determines whether the compounds are good candidates for new drugs.

NI LabVIEW and DAQ Lead to Reliable Drug Discovery

By automating the process of drug discovery, drug manufacturers decrease development time of new drugs and submit the finished product to the FDA for approval sooner. NI motion, vision, and data acquisition products together with the LabVIEW graphical development environment, integrate easily to give drug-discovery machine providers the ability to deliver reliable and low-cost solutions.■

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To download cell-counting example software, visit ni.com/info and enter nsi1407.

To select a stage with the Motion and Stage Advisor, visit ni.com/info and enter nsi1408.

To request a FREE demonstration CD which contains life science and machine vision application examples, visit ni.com/info and enter nsi1409.

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Intelligent, Networked Systems with NI LabVIEW Real-Time

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Using NI LabVIEW Real-Time and the new FP-2000 or FP-2010 FieldPoint Ethernet modules, you can program industrial, distributed I/O systems to run user-defined applications independent from a host or supervisory computer. In addition, you can program them to communicate with computers and workstations on any platform that uses TCP/IP, other FieldPoint modules, and any other Ethernet or serial devices, so you can easily create a reliable, intelligent networked system. Applications particularly suited for this configuration include remote measurement, control, and data publishing across a network; embedded applications, such as data logging for in-vehicle test; and industrial monitoring and control requiring reliable real-time operation. You can take advantage of the rapid development of LabVIEW, the reliable operation of LabVIEW Real-Time, and the modular industrial architecture of FieldPoint to create systems that reduce your development time and make your systems easier to deploy and maintain.

With LabVIEW Real-Time, you can develop your application in the familiar LabVIEW environment on Windows and then download it to run on any RT Series hardware. Your development scales easily from the Windows system to the dedicated real-time operating system running on the RT Series hardware.

Build Embedded Systems with Lower-Cost PXI-8140 RT Series Controllers

The new NI PXI-8145 and PXI-8146 RT Series controllers offer the same LabVIEW flexibility and ease of use as the previous PXI RT Series controllers. Unlike the previous PXI controllers, however, the design of these lower-cost PXI-814x controllers specifically suits embedded systems. These new controllers do not include a hard drive, mouse port, keyboard input, floppy drive, or other peripherals unnecessary in an embedded system. Instead, they include a Compact Flash memory storage device, user-defined LEDs and switches on the front panel, and other features ideal for reliable, embedded, real-time monitoring and control applications.

The following scenarios describe a few simple examples of how you can use the PXI-814x RT controllers or the FP-20xx modules to build intelligent, embedded I/O systems for various applications.

Scenario 1 – Remote Environmental Monitoring

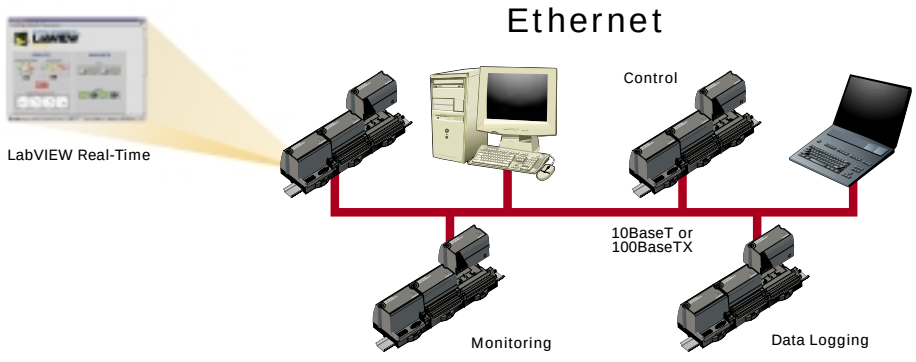
In building environmental monitoring stations, you need cost-effective I/O that can function reliably and report varying conditions while recording information in case of network communication failure. Depending on system requirements, you may need the distributed capabilities of individual intelligent FieldPoint I/O nodes, so you can spread them along the length of a pipeline or scatter them across several kilometers of varying altitudes. These FP-20xx-based I/O nodes can measure temperature, wind speed, humidity, pressure levels, and other signals that require monitoring. These nodes can also perform logical control over valves and other on/off signals or analog control at rates of 1 to 100 times/s, depending on the I/O modules and the number of control loops to run on a given FP-20xx node.

If the environment is within reasonable space constraints, then it may be acceptable to connect everything via Ethernet. However, if distance from node to node is an issue, you can use the serial port to communicate to radio modems or global system for mobile communication (GSM) devices. When deploying these nodes, you may want to store applications and run them at power up on the module. Use LabVIEW Real-Time to develop stand-alone executables. These applications can either start acquiring data immediately or wait for a signal from a supervisory system. These stored applications reside on the Compact Flash memory in the FP-20xx. The Compact Flash memory can also store measurement data or other files. The file I/O programs (VIs) in LabVIEW log data if you need to store data locally instead of continually retrieving it across a network. For higher-speed signals and a higher I/O density, the PXI-814x can offer the same reliability and functionality in data logging and embedded execution as FieldPoint.

You can program industrial, distributed I/O systems to run user-defined applications independent from a host computer.

Scenario 2 – Embedded In-Vehicle Test

For in-vehicle test systems or other portable applications, you ideally need measurement hardware that is space efficient, rugged, and integrated with specialized hardware. Because of the compact size of FieldPoint and the PXI-814x, their ability to run stand alone with LabVIEW Real-Time, and the diversity of measurement, control, and connectivity features, they are good candidates for in-vehicle



Create reliable, embedded, real-time monitoring and control applications with LabVIEW Real-Time, PXI-814x controllers, and FP-20xx Ethernet modules.

test or other portable applications. Intelligent FP-20xx nodes can measure chassis temperature, strain, and other signals in a range of seconds to hundreds of seconds inside the vehicle. Both the FieldPoint and PXI systems can log data directly to onboard Compact Flash memory for retrieval later via the network. Or, both can continuously send data via the serial port to a radio modem in a monitoring computer outside the vehicle. The FieldPoint or PXI systems, programmed with LabVIEW Real-Time, can also perform some PID control and other operations because the LabVIEW Real-Time package includes the PID and Fuzzy Logic Toolkits.

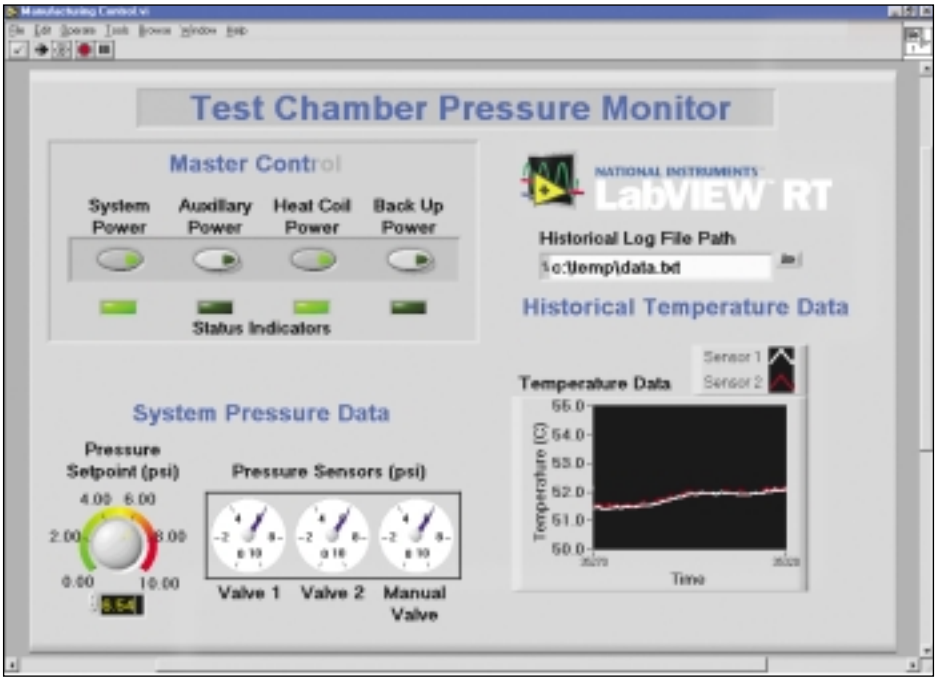
Unlike the previous PXI controllers, the design of these lower-cost PXI-814x controllers specifically suits embedded systems.

To monitor vibration signals for higher-speed data acquisition, the RT Series PXI platform is ideal. You can save stand-alone executables on the permanent storage units using LabVIEW Real-Time so PXI, like FieldPoint, can run headless applications. The highest-performance RT Series PXI systems can run high channel-count acquisitions well into megahertz ranges, as well as perform deterministic real-time control at rates up to 35 kHz, depending on the processing unit and number of simultaneous loops running on a single controller. In addition, RT Series PXI systems can integrate with sophisticated NI SCXI™ signal conditioning systems, increasing the range and connectivity of signals you can use with your system.

The PXI-8140 RT controllers, as well as the other RT Series controllers, can integrate controller area network (CAN), other serial I/O, and even motion control into the system, greatly expanding the capabilities of your onboard acquisition and test system.

Scenario 3 – Machine Monitoring and Control

For signals such as temperature and pressure, you can use the FP-20xx modules and their convenient DIN rail-mounting system to monitor, maintain, and control machinery. For higher-speed operations, such as vibration monitoring, synchronized data acquisition, and motion control, or for high channel counts in a single embedded system, the PXI-814x offers a better solution. With lower costs, higher vibration and shock tolerance, and the onboard Compact Flash memory of the PXI-814x controllers, you can embed the controller, I/O, and smaller custom chassis in the machine itself. You can easily network data and information from that system with the built-in Ethernet and serial ports, or you can run in stand-alone mode only.



With LabVIEW Real-Time, you develop applications in the familiar LabVIEW environment and target them to any RT Series hardware.

Reliable, Real-Time, Embedded Measurement and Automation

The FieldPoint 2000 Family and the PXI-8140 RT Series controllers, combined with the LabVIEW Real-Time development environment, deliver a new solution for real-time, embedded measurement and automation. It addresses your flexibility and rapid development needs in design and validation, while providing the industrial characteristics and reliable stand-alone operation required for systems used in manufacturing and manufacturing test. The compact size of both series of products helps them meet special embedded and space requirements. The Ethernet-based design and serial and wireless communications capabilities continue to enhance your portfolio of networked measurement tools that easily integrate to create your technical enterprise. From intelligent I/O points to PC-based systems to the Internet, National Instruments provides productive software and hardware to integrate an open measurement and automation system – now available for embedded real time.■

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For more information on the FieldPoint 2000 Family, visit ni.com/info and enter nsi1401.

For more information on the PXI-8140 RT Series controllers, visit ni.com/info and enter nsi1402.

ni.com/fieldpoint

PC-Based Spectral Analysis – Accurate and Efficient

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Recent releases include the NI 5620, a 64 MS/s, 14-bit, 36 MHz bandwidth, high-speed digitizer for the PXI/CompactPCI bus, and the NI 4472 for PCI, an eight-channel, 24-bit board with simultaneous sampling and 120 dB dynamic range. For software, NI LabVIEW and Measurement Studio™ perform a variety of routines to calculate and display the averaged fast Fourier transform (FFT)-based power spectrum, cross-power spectrum, and many other types of spectral analyses.

Despite the capabilities, setting up a measurement system that includes spectral analysis requires care. Misapplication can hide important information or even add features that are not actually present in your original signal. To help you avoid such problems, we discuss some fundamentals to consider when selecting your system.

Examining the Frequency Content of a Signal

Understanding the nature of the signals you intend to analyze and what you intend to learn from the analysis helps you specify the software and hardware of your system. When you apply spectral analysis, you examine the frequency-domain version of a signal to identify a sort of recipe for how to construct your original signal using sinusoidal waveforms of varying frequency and amplitude. For signals generated by systems that involve sinusoidal oscillation, this viewpoint can show you information that is not necessarily apparent with the time-versus-amplitude samples. For instance, harmonic distortion is difficult to quantify by inspecting the time waveform. However, by displaying the frequency-domain version of the same signal, you can easily measure the harmonic frequencies or amplitudes and calculate harmonic distortion.

Conversion from Analog to Digital

When you build a computer-based spectrum analyzer, you rely on software for the necessary spectral analysis calculations. This approach requires acquisition hardware to convert the original, continuous signal into a set of computer-friendly samples. The conversion details are important because unexpected differences between the analog and digital versions of your signal can distort your analysis. Such differences are unavoidable – the discrete digital version lacks the between-sample information present in the analog version. Additionally, the amplitude at each sample differs from the continuous version because the conversion process forces you to represent a continuous signal that has infinite possible amplitudes with a digital value that has finite representations.

Sampling theory characterizes the effects of sampling. The theory is at the heart of digital signal processing (DSP), an engineering science that offers some application-oriented guidelines.

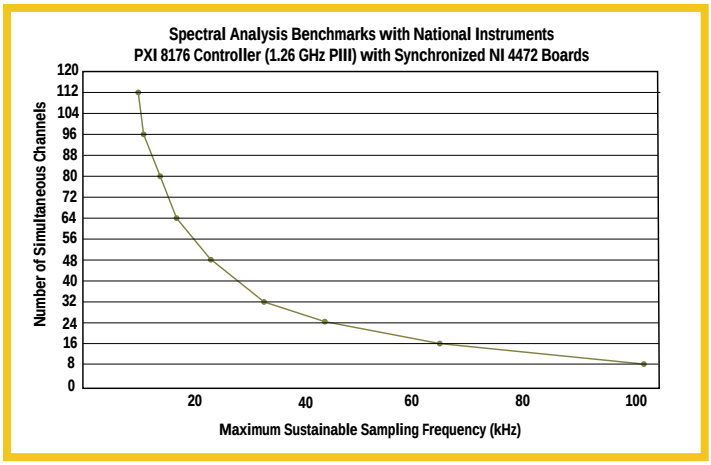
Transforming Digital Version to Results

The samples you acquire show the signal amplitude at evenly spaced intervals in time. To transform these time-domain samples into the frequency-domain representation for spectral analysis, you can apply an FFT-based algorithm. Such algorithms, which ship with versions of LabVIEW, Measurement Studio, and other National Instruments software, are the basis for spectral measurements such as frequency response, impulse response, coherence, and adjacent-channel power.

Common Spectral Analysis Applications
Circuit/system linearity (harmonic/distortion analysis)
Signal/carrier purity (harmonic analysis/SINAD)
Communication band/channel characterization (multitone analysis, frequency response, power in band)
Audio system measurements (frequency response, harmonic/distortion analysis, tone cross talk)
Structural/vibration analysis (frequency response, order analysis)
Noise/harshness (power spectrum, octave analysis, tone detection)
Engine/machine monitoring (spectrum, order analysis, octave analysis)

Spectral analysis is not limited to an FFT-based power spectrum. With a computer-based measurement system, you can choose specific types of spectral analysis to fit your application.

From the computer standpoint, the FFT inputs and outputs are simply numbers in memory. You can assign meaning to these numbers by combining information related to your acquisition with scaling and other operations. Some of the most fundamental information includes the sampling frequency (f_s), the acquisition duration (T), and the number of samples you acquire (N). These parameters set the maximum frequency that you can examine (f_{max}) and the best-case frequency resolution of the results (f_{res}). Because these relationships are the best-case limits, it is common to oversample to ensure that you fully realize the frequency span and resolution that you expect. Some types of acquisition hardware oversample automatically as they convert analog to digital. For instance, the NI 44xx Series of dynamic signal acquisition hardware uses delta-sigma analog-to-digital converters that oversample as part of their acquisition process. With these and other devices, you should gauge the available frequency span from the data sheet specification for bandwidth.



The real-time bandwidth of a computer-based system that performs spectral analysis depends on such factors as the number of channels and CPU type.

Gauging Acquisition and Analysis with Real-Time Bandwidth

Other software concerns relate to the computational speed of your computer. You might hear a specification of real-time bandwidth as a gauge of the maximum acquisition and analysis rate. Assigning a fixed single value real-time

bandwidth is possible for instrumentation that relies on the fixed computational capability of an embedded processor or DSP. For computer-based instrumentation, the real-time bandwidth is a moving target that depends on the specifics of your setup. Channel count, processor speed, and other factors contribute to the possibilities. Such flexibility also means that computer-based instrumentation often does not exclusively perform spectral analysis.

We have seen speed improvements of 70 to 80 percent when moving from single to dual-processor configurations.

Although finding an all-encompassing real-time bandwidth is not practical, you can benchmark specific setups. The figure on page 6 plots the sustainable acquisition rates for real-time gap-free calculation of 1,024-point FFT-based power spectrums for channel counts ranging from 1 to 114. The configuration for the benchmark was a 1.26 GHz PIII PXI controller with 1 to 14 synchronized NI 4472 DSA boards.

Increasing Multiprocessor Speed

The ever-improving performance of processors and other off-the-shelf components ensures that the possible real-time bandwidth continues to improve over time. The same effect applies to multiprocessor configurations, especially for high channel-count applications. Applications you build with LabVIEW are multithreaded, so you can separate channels into different processors to simultaneously process the data and maintain the amount of processing power per channel. To gauge the possible increase in speed that you might gain from a multiprocessor configuration, we completed a LabVIEW application running one-third octave analysis from the Sound and Vibration Toolset on a dual 800 MHz Pentium III processor. With one processor enabled, we could run two channels at 25 kHz bandwidth. Enabling the second processor, the setup could perform the four channels of one-third octave analysis at the same 25 kHz bandwidth. While this example shows a two-fold improvement, we have seen speed improvements of 70 to 80 percent when moving from single to dual-processor configurations.■

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To download the Application Note "The Fundamentals of FFT-Based Spectral Analysis and Measurement," visit ni.com/info and enter nsi1403.

For an interactive tutorial on the fundamentals of FFT-based analysis, visit ni.com/info and enter nsi1404.

ni.com/analysis

Components and Specifications for Spectral Analysis

Consideration	Description	Importance
Analog Anti-Aliasing Filter	• Analog low-pass filter applied before sampling • Should have a cut-off frequency that blocks frequency components above a maximum of half your sampling rate	• Avoids aliasing caused by high-frequency components "folding" into the lower frequency regions because of sampling • The extra signals' components (aliases) appear as frequency components, and you cannot easily distinguish them from real frequency components
Bandwidth	• The frequency range you wish to analyze	• The sampling rate and aliasing protection of your acquisition hardware must accommodate the required bandwidth
Maximum Sampling Rate (f_s)	• The number of samples your acquisition hardware can acquire per second	• The sampling rate, along with the duration of the acquisition, limits the frequency resolution of your result
Spurious-Free Dynamic Range (SFDR)	• Typically expressed in decibels (dB) • The ratio of the highest detectable signal to the maximum peak present in the noise floor (NF)	• Tells you how capable the acquisition hardware is to detect low-signal levels in the presence of high-signal levels
Bits of Resolution (n)	• Tells you how many levels your acquisition hardware can use to represent your signal • Levels = 2^n	• Sets the best-case limit for dynamic range • SNR (dB) = (6.02 · n) + 1.76
Input Noise Density (ND)	• Typically expressed with units of dB$\sqrt{Hz}$ or dB/Hz • The noise level or power present in a 1 Hz bandwidth portion of the spectrum of input signal	• Given the noise density figure and the frequency resolution (see above), you can calculate the noise floor to expect for your measurement • NF = ND + 10 · log(f_{res})
Simultaneous Sampling	• Acquisition systems that simultaneously sample return samples from multiple channels at the same instant in time	• Preserves phase information between channels, thereby enabling cross-channel measurements, such as coherence and correlation
Programmable Input Gains	• The ability to control the amount of amplification or attenuation applied to your signal before sampling	• By setting the input gain of a channel, you can fully use the dynamic range of your input channels • The idea is to match the amplitude swing of your input signal with the full-scale input range on your acquisition device
Signal Conditioning	• The ability of acquisition hardware to provide a constant voltage or constant current supply to transducers	• Many dynamic signal transducers require a power source for built-in signal conditioning
Acquisition Duration (T)	• Time duration of your acquired signal limited by the number of samples your acquisition hardware can continuously acquire into memory or disk	• Determines the frequency resolution (ΔF) of your result • Longer duration yields more resolution • $\Delta F = \frac{1}{T}$

Sampling theory is at the heart of DSP, which offers some application-oriented guidelines.

NI Investment in PCI Meets Current and Future I/O Needs

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The widespread adoption of the PCI specification, originally introduced at 32 bits and 33 MHz and further developed by the Peripheral Component Interconnect Special Interest Group (PCI SIG) since 1992, is due in part to its clear path toward even higher-performance implementations. For years, the PCI SIG and its member companies have envisioned and worked toward implementations using 64 bits and 66 MHz to deliver bandwidth of 528 Mbytes/s.

National Instruments Offers the Latest PCI Technology

Today's PCI architecture offers clear benefits for measurement and automation systems, including:

- Sustained transfer rates – 132 Mbytes/s maximum
- Choice of operating systems – Windows 2000/NT/XP/Me/9x, Mac OS, and more
- True Plug and Play installation and configuration
- Memory-mapped I/O
- Shared interrupts
- Bus mastering for high-speed data transfer between boards and memory
- High quality and low cost

National Instruments has invested heavily in PCI over the last decade and continues to do so today. From driver software and application development environments to test and technical data management packages, NI software features widespread compatibility with PCI. NI also designs our measurement products to take full advantage of industry-standard advancements, using measurement-specific technologies, such as the National Instruments MITE™ bus-mastering ASIC.

Moreover, NI continues to push the envelope in PCI product performance and cost. NI has recently introduced the following cutting-edge PCI products.

PCI-4472 – Dynamic Signal Acquisition

The PCI-4472 DSA module is one of the most accurate products available for audio and vibration applications. The 24-bit A/D converters deliver 120 dB of dynamic range across a bandwidth of 45 kHz. The board features eight simultaneously sampled analog input channels and built-in programmable ICP® conditioning for accelerometers and microphones.

Slated for introduction in late 2003, 3GIO maintains backwards compatibility with PCI software.

PCI-6036E – Multifunction I/O

The PCI-6036E multifunction I/O board offers 16-bit synchronized input and output, which makes it an ideal low-cost option for stimulus-response measurements. The PCI-6036E has 16 single-ended (or eight differential), 16-bit analog inputs that sample at a maximum of 200 kS/s, two 16-bit analog outputs, eight digital I/O lines, and two 24-bit counter/timers.

PCI-5112 – High-Speed Sampling

The dual-channel PCI-5112 high-speed digitizer simultaneously acquires waveforms with bandwidths up to 100 MHz, sampling at up to 100 MS/s with 8-bit resolution. In random interleaved sampling mode, the digitizer can sample at 2.5 GS/s. The digitizer comes standard with 16 MB of memory per channel and has an optional upgrade to 32 MB of memory per channel.

PCI-6534 – High-Speed Digital I/O

The PCI-6534 high-speed digital I/O device delivers 32 lines of 5 V/TTL digital I/O and start and stop triggering. It can transfer in 8, 16, or 32 bits. The NI 6534 also features two independent data paths with 32 MB of onboard memory per data path. The 20 MHz clock rate of the PCI-6534 enables transfer rates of 80 Mbytes/s for 32-bit words.

PCI-X is the first I/O industry standard to break the 1 Gbyte/s barrier in sustainable bandwidth.

Preparing for the Future of I/O

In fact, some products are now making their way into the marketplace featuring a higher-performance addendum to PCI, known as PCI-X. Intended initially for use in servers and workstations, PCI-X is the first I/O industry standard to break the 1 Gbyte/s barrier in sustainable bandwidth.

The demands of emerging and future computing models, however, ultimately exceed the bandwidth and scalability limits of today's PCI and even PCI-X architectures. Technologies, such as CPU speeds that exceed 10 GHz, faster memory speeds, higher-speed

graphics, 1 and 10 Gbits LAN, InfiniBand fabrics, and more, drive the need for much greater internal system bandwidth.

As a result, the PCI SIG along with computer-industry leaders in August 2001, decided to endorse the Intel Corp. third-generation I/O technology as the next-generation architecture for system I/O. The technology, dubbed 3GIO, will ultimately succeed PCI and PCI-X in computers to introduce higher-speed connection of components inside a system and offer increased bandwidth for emerging applications.

National Instruments has invested heavily in PCI over the last decade and continues to do so today.

What Is 3GIO?

Preliminary details indicate 3GIO is a point-to-point, full serial interface, scalable beyond 10 GHz or to the theoretical limits of copper. Slated for introduction in late 2003, it has a speed of 2.5 Gbits/s per channel and initially provides 200 Mbytes/s bandwidth.

Additionally, 3GIO plans call for compatibility with switching and packet prioritization, hot-plug and hot-swap capability, power-management capabilities, and more. Perhaps most importantly, the PCI SIG dedicates itself to maintaining backwards compatibility with PCI software, thus enabling you to preserve your existing software investment as you transition to the higher-speed bus.

Does 3GIO Affect You?

For today's measurement and automation systems needs, the PCI and PCI-X architectures have considerable performance potential to meet local I/O needs well into the future.

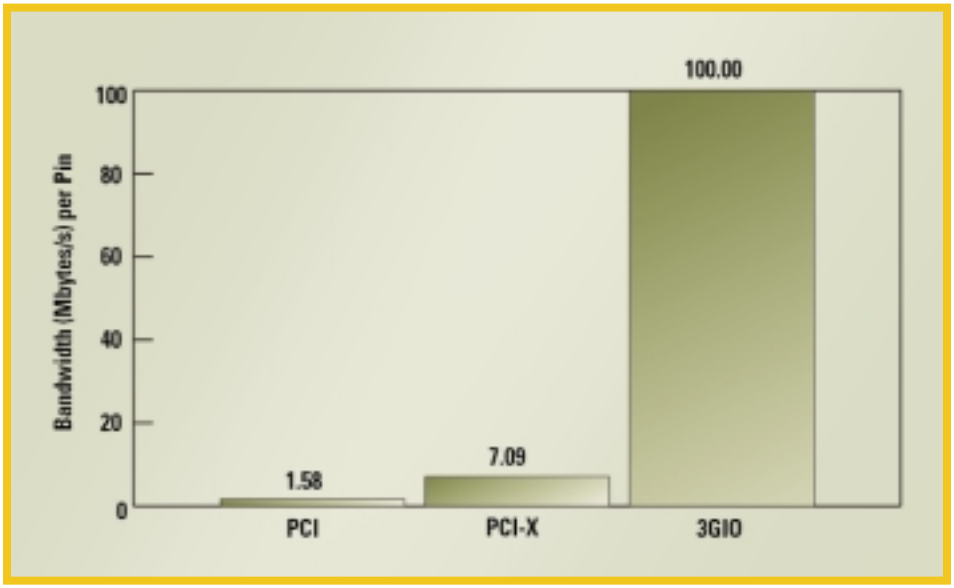
"The debut of 3GIO does not mean that PCI and PCI-X will go away anytime soon," said Roger Tipley, chairman of the PCI SIG.

For many years to come, conventional PCI will continue to be the preferred I/O solution for consumer and commercial laptops and desktop PCs. However, PCI-X not only handles the needs of today's servers and workstations, but is also scalable enough to continue as the preferred interconnect in high-performance servers and workstations for quite some time.

NI Prepares for the Future

NI is closely watching 3GIO development and plans to immediately begin work on products once the specification releases. Because of National Instruments computer-based approach, existing product development strategy, and proven architectures and technologies, NI is in position to be one of the first to provide your 3GIO products as your measurement and automation needs evolve.■

To download the white paper on the MITE and PCI bus mastering, "Doing PCI Right – The Advantages of MITE-Based PCI Data Acquisition," visit ni.com/info and enter nsi1405.



The PCI SIG commits to move toward higher-performance implementations.

You Achieve Faster Data Throughput with NI MITE ASIC

An important aspect of creating computer-based measurement and automation systems is high-speed data throughput coupled with real-time, continuous data processing. Off-the-shelf bus-mastering chips are usually not optimized for measurement devices. For example, you might be able to transfer a quick burst of data to RAM, but you cannot do this continuously. For this reason, NI developed the MITE ASIC for use on all NI PCI products.

Using up to three separate direct memory access (DMA) controllers and a technique called on-the-fly scatter-gather, the MITE seamlessly distributes data at rates up to 100 Mbytes/s – even over noncontiguous memory areas typical of virtual memory-based operating systems, such as Windows 2000/NT/XP/Me/9x. With these higher data transfer rates, you gain faster, more reliable measurement results.■

ni.com/measurements

High-Speed 12-Bit DAQ with Twice the Memory

The NI 6115 single-slot data acquisition board for PXI is now available with an onboard memory option to hold 32 million analog input and output samples. NI-DAQ™ driver software automatically handles the onboard memory, so you avoid extra programming challenges.

Reliable Onboard Memory

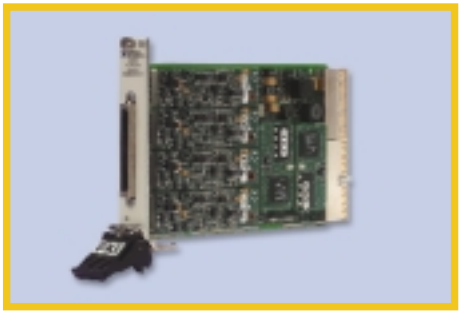
The NI 6115 DAQ device is capable of 10 MS/s per channel with a 5 MHz bandwidth on each of four analog input channels. The PCI backplane of the PXI chassis needs to consistently handle an 80 Mbytes/s transfer rate for a full-speed analog input operation on all four channels of an NI 6115 device. The PCI backplane can perform at this speed only if no other computer operations occupy significant bus bandwidth at any point during the analog input operation. Onboard memory acts as a data safety net when other devices need the PCI bus bandwidth during your acquisition.

Because NI 6115 DAQ boards can also synchronize using phase-locking circuitry and the PXI synchronization bus, you can fill a PXI chassis with the NI 6115 and create up to 68 synchronized analog inputs, each with 10 MS/s, 12-bit inputs. Onboard memory is crucial in these types of high channel-count applications for both analog input and output operations.

Analog Input Architecture

You must complement the resolution of high-speed 12-bit analog-to-digital converters with high-quality analog input design. NI designed the PXI-6115 so it can achieve -120 dBm/Hz of input noise density and 80 dB of SFDR when set for a ±10 V range. Both of these specifications contribute to accurate results in both the time domain and the frequency domain.

Overall, this mixed I/O high-performance DAQ board solves your specific high-speed applications when measurement quality really counts.■



NI 6115 onboard memory ensures reliable data.

To download the manual of complete NI 6115 specifications, visit ni.com/info and enter nsi1410.

ni.com/measurements

Calibration for High-Speed Digitizers and FieldPoint

The NI external calibration offering has expanded to include high-speed digitizers and FieldPoint modules. You can now calibrate these products through our calibration services or with NI Calibration Executive.

What Is Calibration and Why Is It Important?

Calibration is the process of verifying and, if necessary, adjusting a measurement device to meet its specification. Proper and timely calibration helps you improve accuracy, ensure consistency, and meet quality requirements. You can calibrate most devices both internally and externally. You internally calibrate devices to adjust for environmental conditions, such as temperature. Similar to a self-calibrate function, internal calibration compares measurements to onboard references and adjusts if necessary. Over time, these onboard references drift and need calibration to a high-precision external standard. Metrology labs that maintain traceable standards perform external calibration.

NIST-Traceable Calibration Certificate

External Calibration Options for NI Devices

NI externally calibrates its measurement hardware at the factory and ships it with an NIST-traceable certificate of basic calibration. To maintain measurement accuracy, NI recommends annual external calibration of your devices.

Calibration services are an easy way to calibrate your measurement hardware. The first level is a basic, NIST-traceable recalibration process that conforms to the relevant clauses of ISO 9002. The next level is detailed calibration, which provides calibration to a specified standard, such as ANSI-Z540. You can now send your NI products, including high-speed digitizers, most FieldPoint devices, and many SCXI terminal blocks, to NI for detailed calibration. Additionally, this service is available for National Instruments E Series multifunction DAQ, SCXI, analog output, digital multimeter (DMM), logger, and DSA modules.

Automated Calibration for Many NI Devices

The NI Calibration Executive is an integrated environment for verifying and adjusting National Instruments measurement devices. Designed primarily for metrology laboratories that calibrate many devices in a year, Calibration Executive provides automated calibration for many of our measurement devices. For products handled by Calibration Executive or detailed calibration services, National Instruments also publishes manual calibration procedures.■

For more information on calibrating your measurement device, visit ni.com/info and enter nsi1411.

ni.com/measurements

New I/O Module Makes High-Voltage Testing Easy

Measuring high-voltage process signals can be a challenge that requires custom signal conditioning, consisting of bulky and high-priced stand-alone boxes that restrict system flexibility. Now, you have a new option for accurate high-voltage analog measurements with the National Instruments FieldPoint FP-AI-102 module. The module features 12-bit resolution and expands the FieldPoint product line with the ability to handle voltage measurements up to 120 V.

NI FieldPoint is a distributed industrial data acquisition and control system consisting of one or more banks of modules. Each bank contains a network interface module, such as Ethernet, serial, FOUNDATION Fieldbus, or wireless, and a combination of I/O modules to monitor and control voltage, current loops, discrete signals, relays, thermocouples, resistance-temperature detectors (RTDs), and more. These systems are either networked to a central computer or installed with an embedded controller that collects information, performs calculations and feedback loops, and logs historical data. You control these systems using NI LabVIEW and LabVIEW Real-Time.

The FP-AI-102 makes battery, fuel cell, and high-voltage testing easy.

New High-Voltage Analog Module for Fuel Cell Testing

With growing investment in fuel-efficient hybrid vehicles, research of high-voltage battery packs and fuel cells has gained momentum. Monitoring the voltage from each battery in a pack or from each membrane in a fuel cell stack indicates the health of each component and enables evaluation of various test configurations. With the FP-AI-102 module, which has input ranges from -120 to +120 V, you can easily monitor the status of these systems. This module is also ideal for testing the new 42 V systems designed for automobiles.

A FieldPoint system can also integrate other signals into a test system. For battery-pack testing, you often need to monitor the temperature of each battery while charging or use a charge equalization system to ensure even voltage across the battery pack. The NI FieldPoint system can measure thermocouples or RTDs for temperature monitoring and turn on and off relays for charge equalization. With the modular, user-defined nature of FieldPoint, the new high-voltage, analog input module, and the powerful flexibility of LabVIEW, you can easily create custom solutions for high-voltage applications.■

To download the data sheet on the FP-AI-102 module, visit ni.com/info and enter nsi1412.

ni.com/fieldpoint

High-Performance 16-Bit DAQ Enhances Portable Platform

The DAQPad™-6052E for IEEE 1394 (Firewire™) brings National Instruments highest-performance 16-bit E Series DAQ product to a portable platform. The DAQ board provides 16 single-ended or eight differential channels, a 333 kS/s sampling rate (continuous), and 16-bit resolution. Additionally, this device contains two 16-bit analog outputs at a 333 kS/s update rate, two 24-bit counter/timers, and eight digital I/O lines. With the release of the DAQPad-6052E, combined with National Instruments DAQPad-6070E device, NI offers our two highest-performance E Series DAQ products in a portable platform.

With the DAQPad-6052, you can acquire and log data at rates up to 333 kS/s, continuous.

The DAQPad-6052E for IEEE 1394 is available in a mass termination model. The mass termination model contains a 68-pin connector that cables to standard E Series accessories, such as connector blocks and signal conditioning. It is ideal for use with the portable SCC signal conditioning system, providing signal conditioning and connectivity on a per-channel basis.

You can use the E Series DAQ board with the SCC signal conditioning platform and our new VI Logger configuration-based data logging software to achieve a ready-to-run, portable data logging system.

Using the high-speed IEEE 1394 link to your PC, you can take full advantage of the 333 kS/s sampling rate of the DAQPad-6052E device. In fact, you can daisy chain up to four of them on the same IEEE 1394 bus with no degradation in performance and synchronize them through the RTSI bus.

The new DAQ board for IEEE 1394 comes with NI-DAQ 6.9, the NI driver software for DAQ, which handles the IEEE 1394 bus interface. With NI-DAQ, configuration and programming of external National Instruments DAQ products, such as the DAQPad-6052E, is identical to using NI plug-in DAQ boards. LabVIEW applications developed for other E Series DAQ boards also work with the DAQPad-6052E for IEEE 1394.■

To download the data sheet on the NI DAQPad-6052E for IEEE 1394, visit ni.com/info and enter nsi1413.

ni.com/portable

Understanding Accuracy with NI Data Acquisition

National Instruments provides absolute accuracy specifications, so your measurement stays within a certain range of the actual voltage. While finding the absolute accuracy ranges for a National Instruments data acquisition board is easy, the challenge arises when comparing DAQ options from manufacturers who use various methods to provide accuracy information. The best way to compare boards is to run a simple set of tests explained online at NI Developer Zone™.

The NI Accuracy Calculator helps you compute the accuracy of your measurement system.

Although you may not always have access to the hardware, you can still compare specifications.

One specification is relative accuracy, or the maximum deviation from a perfectly straight line when you plot all the discrete digital codes of an analog-to-digital converter against the actual voltage values. The NI PCI-6036E multifunction I/O board, for instance, is a low-cost 16-bit multifunction board with a typical relative accuracy of ±1.5 least significant bits (LSB).

A second specification is system noise. System noise is the deviation from a 0 V measurement when the analog inputs are properly grounded. System noise generally includes quantization error. The amount of system noise is often equally as important as the distribution of system noise. If the system noise has even distribution around 0 V, software can easily average the system noise.

Another set of standard specifications on a DAQ board is the gain error and offset error. Both specifications are properties of the instrumentation amplifier. When comparing the gain and offset errors, you must check that these values represent the error after you apply the gain to the signal.

National Instruments calibrates E Series DAQ boards at the factory and ships them with NIST-traceable calibration certificates. The boards also have onboard calibration circuitry, so you can periodically calibrate the board with no extra equipment.■

To use the NI Accuracy Calculator for our E Series data acquisition boards and signal conditioning products, visit ni.com/info and enter nsi1414.

To test the accuracy of a DAQ board, visit ni.com/info and enter nsi1415.

ni.com/measurements

Acquisition Tools for Noise and Vibration Diagnostics

The diagnostics of noise and vibration phenomena involve a special data acquisition methodology. The dynamic signals coming from the transducers can range from micro-volts to volts. An acquisition front end with a dynamic range as high as 120 dB is required. Common noise, vibration, and harshness (NVH) sensors have embedded electronics that convert the signal coming from a piezoelectric crystal into a voltage. This integrated electronic piezoelectric (IEPE) circuitry requires a stable DC power source and AC coupling of the sensor to the analog front end. Accurate noise and vibration data correlation in the frequency domain requires that all channels are simultaneously sampled and that there are linear phase response and small phase error from channel to channel.

Feature	NI 4472	NI 4551/52	NI 4451/52	NI 4454
Platform	PCI and PXI	PCI	PCI	PCI
Number of Channels	eight in or four in	two in/out, or four in	two in/out,	four in
Dynamic Range	120 dB	90 dB	90 dB	90 dB
Resolution	24 bit	16 bit	16 bit	16 bit
Maximum Sample Rate	102.4 kS/s	204.8 kS/s	204.8 kS/s	51.2 kS/s
Driver	NI-DAQ	NI-DSA™	NI-DAQ	NI-DAQ
Input Configuration	unbalanced differential	differential/ single ended	differential/ single ended	single ended
Processing	host computer	onboard DSP	host computer	host computer
ICP	yes, built in	yes, with BNC-2140	yes, with BNC-2140	yes, with BNC-2140
Connectivity	SMB	BNC	BNC	BNC

Compare NI products specifically designed for noise and vibration applications. NI software further advances the range of these instruments.

The NI 4472 DSA module adds a new level of performance and affordability to noise and vibration diagnostic front ends. Each of the module's eight input channels has software-controlled ICP signal conditioning and AC/DC coupling that make interfacing your transducer simple. The NI 4472 has a dynamic range of 120 dB, sample rates up to 102.4 kS/s, and phase mismatch of 0.1 degree (at 1 kHz). You can synchronize multiple NI 4472 DSA modules for PCI via the RTSI bus. You can use the NI 4472 DSA module for PCI and PXI in many application areas, such as automotive NVH testing, audio test and measurement, and machine-condition monitoring.

NI offers an endless set of tools that you can use to solve your noise and vibration diagnostic needs, including LabVIEW graphical development environment, the Sound and Vibration Toolset, and the Order Analysis Toolset. With NI software and hardware, you can create a flexible system to meet your needs.■

To download start-up kits and application guides, visit ni.com/info and enter nsi1416.

ni.com/automotive