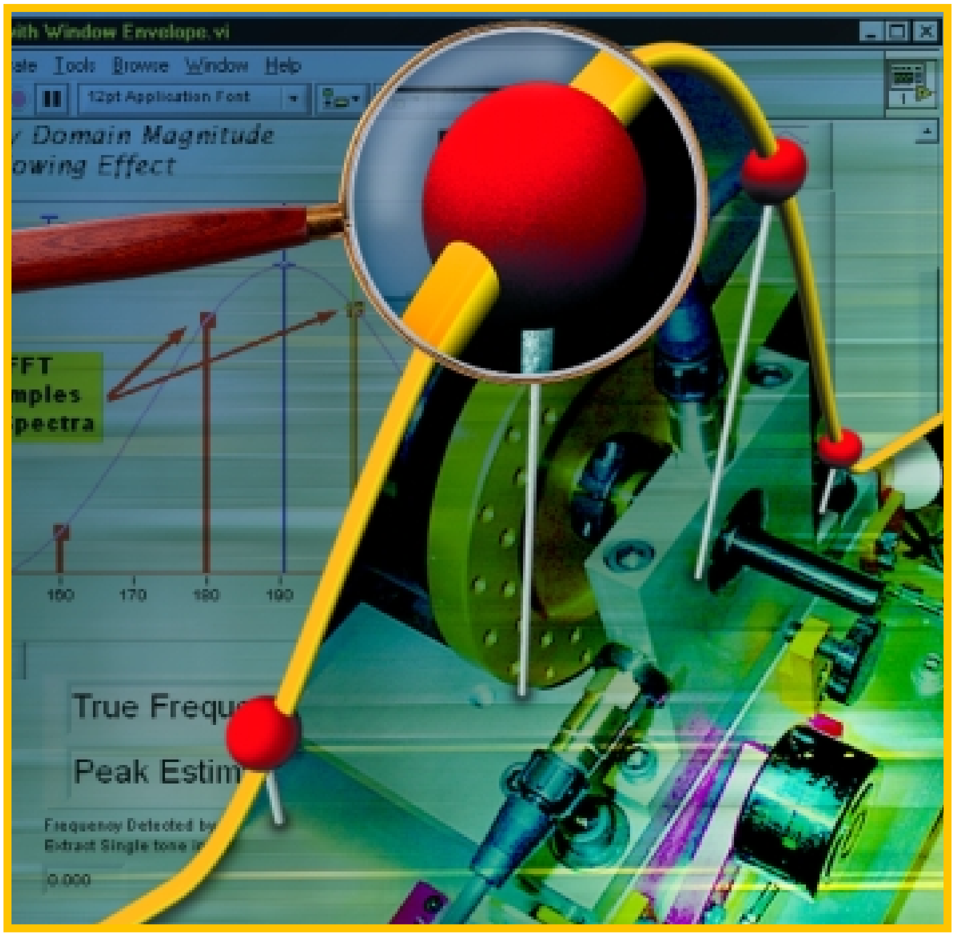
Instrumentation newsletter

Technical News from National Instruments

Fourth Quarter 2000



Speeding Your Measurements with Performance Algorithms

Test time has become a critical factor in the high-volume production of devices, such as cell phones, pagers, and televisions.

As you work to speed up your test, you might first consider hardware changes. However, with the release of LabVIEW™ 6*i*, you have an interesting alternative – speeding up tests through efficient measurement analysis. Among the new tools are several that employ high-speed FFT-based algorithms – Extract Single Tone Information and Frequency Response Function (FRF). With these new tools, you can build programs that can dramatically speed up frequency measurements.

Accurate Frequency Determination

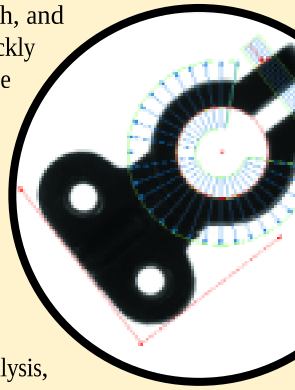
You can measure frequency a number of ways. If you have a low-noise signal, you most often use a frequency counter. It measures the time duration of a period, and then computes the frequency as the reciprocal of the period length. Often this technique only uses zero crossing

continued on page 4

Make the Move from Signals to Images

National Instruments IMAQ™ Vision 6.0 simplifies machine vision software development for new and experienced vision users.

When you first start an image processing or machine vision project, you have a large choice of exciting software algorithms. If you are a measurement user with basic knowledge of signal processing, math, and statistics, you can quickly learn to apply machine vision operations to solve a wide range of applications, and you can use your basic measurement background operations, such as histogram, threshold, morphology, blob analysis, edge detection, and pattern matching, to quickly develop inspection applications.



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Standardized Test Systems Improve Productivity and Cost

To standardize at the test management platform level many companies have turned to TestStand™, National Instruments off-the-shelf, customizable test executive. TestStand provides a test management architecture for standardizing manufacturing test systems.

Reducing cost and increasing productivity is an obvious goal of many

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NATIONAL INSTRUMENTS™

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Here's What You Missed...

- Understanding how networks are changing how we take measurements
- Discovering the power of LabVIEW 6*i*
- Learning about user-defined instruments to reliably test your product in real time

...If You Missed the Last Issue.

For more information, check the appropriate past newsletter issue on the reply card.

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Instrumentation newsletter

Volume 12, Number 4 **Fourth Quarter 2000**

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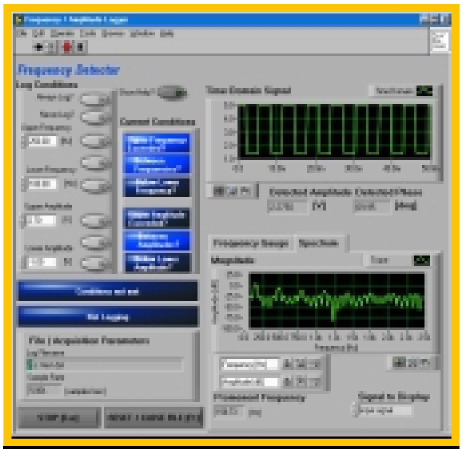
E-to-E Redefines Product Development

Thank you to all of you who attended our best ever NIWeek™ 2000 – our first NIWeek of the new century. With you, we have taken advantage of the PC revolution for the past decade to redefine measurement and automation. In the next decade and beyond, the Web is redefining our industry, and we know that together with you, we are leading this new generation.



LabVIEW 6*i* is an exciting step toward improving productivity.

Continuing the Measurement Revolution

How will the Web change our industry? Through the Web, you can take advantage of a common communication strategy. The Internet is an easy-to-use, widespread, and effective standard. We are all familiar with the term b-to-b, or business-to-business. B-to-b technologies have dramatically improved supply chain efficiency because the Web has been a "unifying" technology that made it possible for separate companies to do business together without reimplementing their information systems to a common system.

Now our challenge is to bring the Web to bear on product development to bring new efficiency and productivity to scientists and engineers. Today many design, manufacturing, and support teams, often across facilities and different companies, must collaborate to produce complex products. These many groups of engineers function as small companies. They must execute independently for speed and efficiency, but they must coordinate and use the work of others to accelerate the pace of innovation and speed of time-to-market.

Now we can use the power of the Web across the technical data enterprise to help you manage your data and usher in a new era of engineer-to-engineer efficiency and productivity. This new era is called e-to-e.

A New Era of Productivity Ahead

We see a new era of technology and tools for scientists and engineers. The potential of the Web goes far beyond using b-to-b technologies just for the supply chain. Now we can use the power of the Web across the technical data enterprise to help you manage your data and usher in a new era of engineer-to-engineer efficiency and productivity. This new era is called e-to-e.

E-to-e means engineers can leverage the work of others to increase their own expertise and speed. It means efficiency – you are more productive than ever. It means empowerment – you define your own solutions faster and for less cost than ever.

The magnitude of the opportunities before us to improve productivity is tremendous. As you saw at NIWeek, LabVIEW 6*i* is just one exciting step to the future of improved productivity. You are empowered to define your networked measurement and automation solution. Many other Web-enabled products are here today, and we have much more planned for the future. Together, our opportunities go beyond measurement and automation solutions; with e-to-e, they extend across product development, across the technical data enterprise, and around the world.

John Graff, VP Marketing

ni.com

Automating Fiber Optics Using NI PXI™, Motion, and Vision

by Pierre Bernard, Ph.D, Vice President, Product & Technology Development, LightPath Technologies

The Challenge: Developing a flexible telecom manufacturing test system that LightPath scientists could use throughout their company – from R&D to the production floor.

The Solution: Integrating an automated PXI-based test system that technicians can easily change and update across the enterprise as test requirements change.

While many fiber optics parts are still hand assembled, the Albuquerque division of LightPath Technologies designed an integrated, automated approach to produce collimators, which are gradium lenses fused to fiber-optic cable that help direct light. The performance and reliability of these intricate parts are integral to the overall performance of telecom systems.

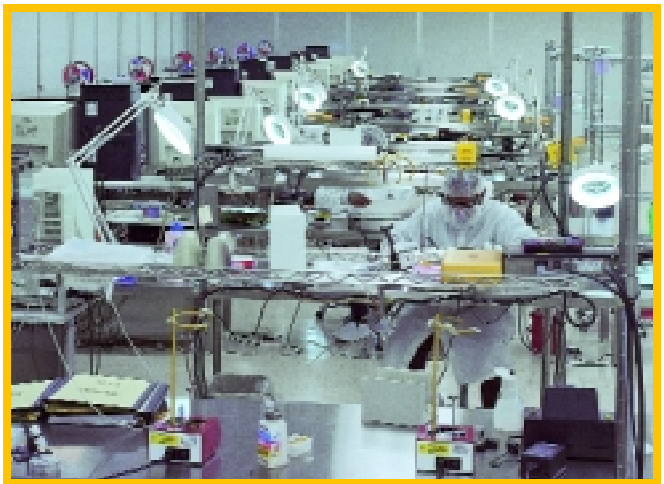
One of the main benefits of our system is that we could develop a custom solution with all the tools we needed, from motion, to vision, to data acquisition, gaining test flexibility and reliability in the process.

With an automated system approach, we gained efficiency, producing more collimators in less time. We decided to base our system on the PXI platform along with MXI™-3 for additional slot capability, and included National Instruments motion, vision, DAQ, signal conditioning, and LabWindows™/CVI, a component of Measurement Studio™. With these systems, technicians could perform various positioning, fusing, and cutting tasks required in the collimator manufacturing process.

From the R&D Lab to the Production Floor

We developed our first system in the lab, and still use it today for making tweaks and enhancements to our factory floor system. Building these complete systems goes quickly, and building them on PXI proved seamless.

The production floor, housed in a clean room environment, has an array of workstations with extra space for additional machines. The PXI chassis holds machine vision (IMAQ), motion control, DAQ, and GPIB hardware. Two monitors, driven by a computer, display the visual results. The motion controllers, cameras, and signal conditioning are housed in a black box, which also contains all the mechanical equipment used in the manufacturing process.



We built a flexible, PXI-based test system to use across our enterprise.

The fusing machine works by threading fiber-optic cable down from a large spool to small roller blade wheels, using motion control to fine-tune the cable position. From there, a laser welds the cable with the lens – this patented laser process takes about a minute per collimator. NI vision products ensure precise alignment between the lens and the laser. The entire system uses three cameras along with two different vision boards. A digital camera and board combination looks at the beam coming out of each collimator, then performs feedback diagnostics and obtains quality control on the end product. This quality check ensures that the system spots any defects up front.

Other CCD cameras look at the angle between each fiber and lens combination, measuring and adjusting the angle to see if it lies within certain tolerances. LightPath has set up process control parameters for this system, determining what is acceptable and what is not. IMAQ hardware and software ensure that these parameters are met.

Data acquisition boards perform diagnostic tests on the overall system, including measuring encoder feedback, digital I/O for the relays, and performing other measurements to ensure the process lies within the accepted parameters.

Similar System Performs Polishing

A second system using motion, vision, and data acquisition, based on the machines used in the production floor, performs coating and polishing functions on the lenses before they reach the automated test process. We found it simpler to borrow the technologies we had already invested in our manufacturing test stations to perform the required polishing tasks. The polishing system is also incredibly fast, taking only about three seconds per lens to position, move, and inspect each part.

Ease of Integration

One of the main benefits of our system is that we could develop a custom solution with all the tools we needed, from motion, to vision, to data acquisition, gaining test flexibility and reliability in the process. If we need to make changes to the system, we can do them from a central office, making it easy to perform tweaks on-the-fly. Throughout the system development, we have improved our control and completed a system that is robust and solid.

For more information, contact Pierre Bernard, LightPath Technologies, e-mail pbernard@light.net, or Web light.net

ni.com/success

Speeding Your Measurements with Performance Algorithms

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information and can be quite sensitive to noise. For noisier signals, you can extract the frequency using a spectrum analyzer, but this technique suffers from relatively poor frequency resolution for a given measurement duration. For example, a resolution of 1 Hz requires a measurement duration of 1 s.

When using the FFT-based method to determine frequency, it is common to try to interpolate to better frequency accuracy by compensating for the smearing (spectral leakage) that occurs between neighboring channels. This technique has been taken to new heights in LabVIEW 6*i* in a patent pending technique that pinpoints highly accurate frequency very rapidly. For example, you can compute the frequency of a 1 kHz sine wave with a better than 10 digit resolution of 1 μHz in less than 50 ms. This seems to violate the principle that the measurement time is the reciprocal of the desired frequency resolution, which in this case would require one million seconds. However, because you

As you work to speed up your test, you might first consider hardware changes. With the release of LabVIEW 6*i*, you have an interesting solution – speeding up tests through efficient measurement analysis.

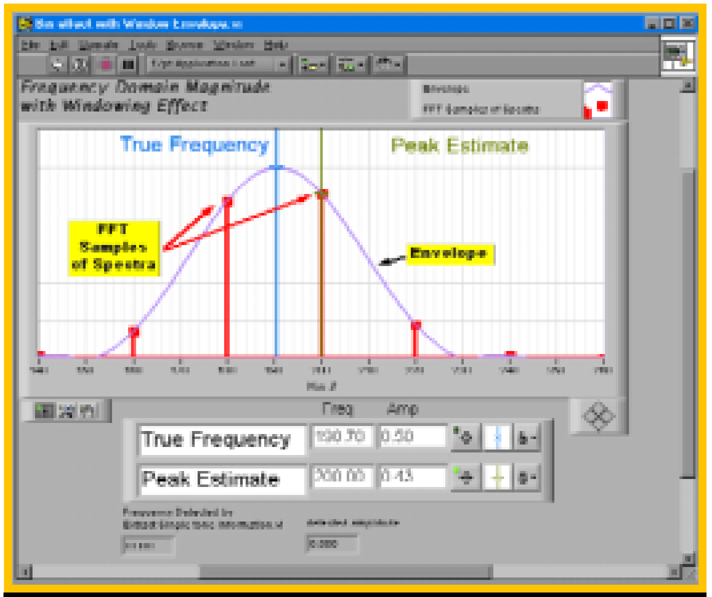
supply the instrument with a signal known to be clean and stable, these interpolation techniques are perfectly legitimate. Based on this *a priori* knowledge, you can use sophisticated FFT-based techniques, to extract not only the frequency, but as a "free" by-product, also the amplitude and phase of the signal with high resolution.

The Extract Single Frequency algorithm provides noise rejection by combining FFT spectrum analysis with advanced curve fitting. The table shows the typical frequency and amplitude resolution for various signal-to-noise ratios. Remarkably, this algorithm can extract a frequency with about four-digit accuracy with a signal-to-noise ratio of -20 dB, in other words, the noise level is 10 times higher than the signal being measured!

The Extract Single Frequency function (as it is known in LabVIEW 6*i*) adapts automatically to data from A/D converters of any sampling frequency, resolution, and block length. The new waveform data type in LabVIEW 6*i* makes this possible, without the user handling these parameters. This function is also used internally in the new Distortion functions, which give significantly improved accuracy in the determination of the fundamental and harmonic components.

A side benefit of this new function is the Residual Signal Output, which equals the input signal minus the precisely determined frequency component. This signal may then be fed to other products in LabVIEW for additional analysis, for example for viewing of close-in phase noise, which normally would be hidden under the skirts of a typical spectrum analyzer filter (analog or digital).

Despite their flexibility, speed, and accuracy, these types of algorithms are not what you would normally find on a traditional stand-alone instrument. Deploying such algorithms for your measurements is only now possible because of the power of the PC platform.



A raw FFT results in samples of your spectra. The Extract Single Frequency VI provides more accuracy by interpoling between these samples.

Typical Frequency Versus Amplitude Resolution

Noise Level dB Ref. Signal	Frequency Resolution digits	Amplitude Resolution digits	FFT Size points	Computational Time 350 MHz PII
-160	11.5	8.5	2,000	50 ms
-140	10.5	7.5	2,000	50 ms
-120	7.5	7.5	2,000	50 ms
-100	7.0	6.5	2,000	50 ms
-80	7.5	5.5	10,000	80 ms
-60	6.5	5.0	10,000	80 ms
-40	7.5	4.5	100,000	700 ms
-20	7.0	3.5	100,000	700 ms
0	6.5	2.5	100,000	700 ms
20	4.5	1.5	100,000	700 ms

Turbo-Charged Frequency Response Measurements

The Frequency Response Function (FRF) is familiar to most engineers as the measurement of the gain and phase of a system. A classic example of where you might apply such a measurement is in acoustic testing of devices, such as cell phones and speakers. Traditionally for such measurements, you might sweep a sine generator with a known flat amplitude and measure the response using a voltmeter. However, this traditional measurement technique rests on several assumptions that cannot always be met:

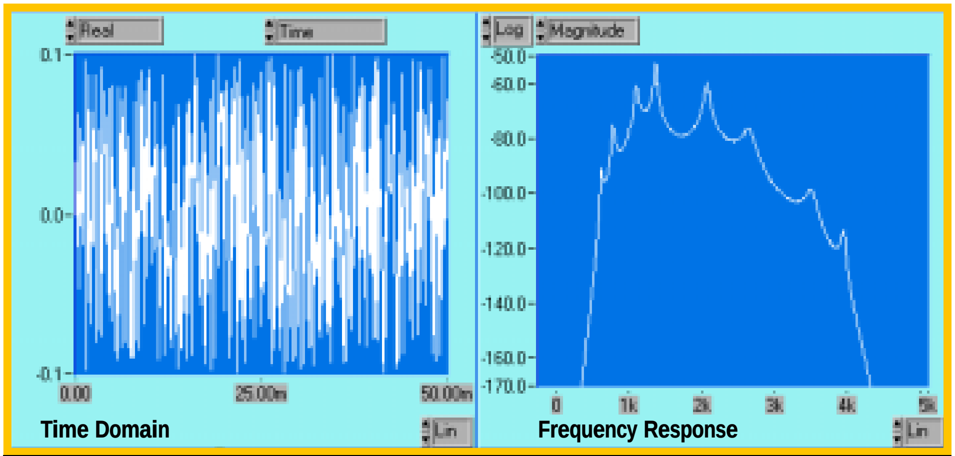
1. The simulation is constant as a function of frequency and does not drift as a function of time.
2. The unit under test (UUT) or the measurement chain does not introduce noise into the measurement.
3. The UUT does not create any distortion.
4. The output signal is actually correlated to the input signal.
5. The UUT characteristics do not drift during the measurement.

You can greatly reduce the risks related to these assumptions by using the new Frequency Response Function in LabVIEW 6*i*. The algorithm used in LabVIEW is based on a technique familiar to the acoustics and vibration disciplines, but to date has not been as well known in other fields, such as general electronics and communications test. It involves measurement of the causal relationship between the input and output signals to the UUT. In other words, the technique reduces the effects of noise and distortion by only including the output signals at each frequency that are correlated to the input signal.

The bottom line is simple – you can dramatically improve both measurement speed *and* accuracy, and the function is simple to implement using LabVIEW.

Another benefit of the technique is that you can dramatically increase the speed of your measurement relative to the traditional swept-sine method mentioned earlier. The speed increase is possible because you can use a broadband excitation source with the LabVIEW 6*i* Frequency Response Function VI. (The use of a broadband excitation signal is possible because the VI computes the frequency response as the ratio, both gain and phase, of output to input at every frequency in the spectrum.)

Broadband excitation stimulates the UUT by applying a test signal, such as white noise, a chirp, or an impulse function that contains all frequencies. This increases speed because you can measure the frequency response of the UUT in a single measurement, rather than in single-frequency steps of the swept sine technique. Performing a single measurement is typically much faster than performing a series of measurements because the measurement time depends on your frequency resolution requirements. For example, if a resolution of 2 Hz is required, then the swept sine generator must dwell at least the reciprocal of this resolution (1/2 second) at each frequency of interest to get a correct measurement. With broadband excitation, the dwell time remains the same, but it only occurs once. For example, if the frequency response measurement requires 200 measurement points, then the FFT-based technique would perform the measurement up to 200 times faster. More specifically, if you need 20 Hz frequency resolution over a 4 kHz range for audio tests of a telephone or cell phone, the measurement time could be as low as 50 ms.



Frequency Response Measurement Using Noise Excitation in Less than 100 ms

DSP Measurement Analysis for Speed

With the new LabVIEW 6*i* DSP measurement tools for Frequency Response and Detection, you can improve your measurement speed. And, with this speed increase, you can reduce throughput time on a manufacturing line and use the time saved to perform other measurements, to perform averaging to reduce noise and improve accuracy, or to increase frequency resolution.

The bottom line is simple – you can dramatically improve both measurement speed *and* accuracy, and the function is simple to implement using LabVIEW. Required hardware is a two-channel A/D converter along with a low-cost D/A converter for signal generation. Because errors from the generator are automatically removed, its accuracy and stability are not critical. In addition, the two input channels do not even need to be perfectly matched. You can measure their relative gain/phase error by applying the same broadband signal to both channels, and you can then correct this error in the subsequent measurement.

Carsten Thomsen, Consultant
E-mail pxi@mail.dk or Web pxi.dk

For more information on the Tone Detection algorithm, visit ni.com/info and enter **newsletter**.

ni.com/labview

Make the Move from Signals to Images

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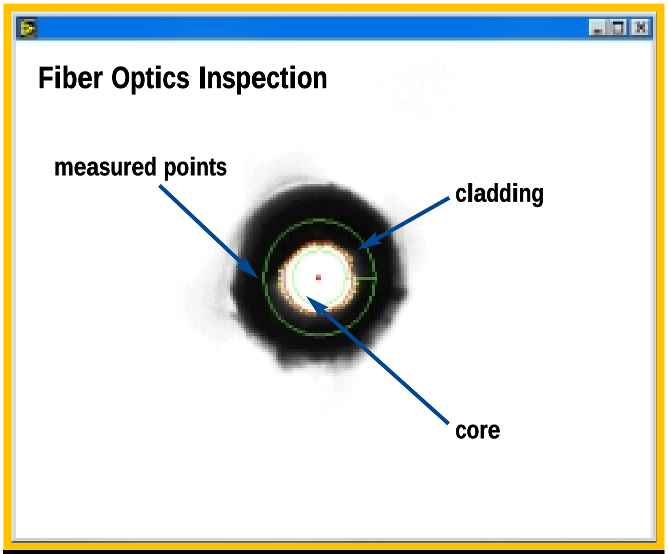
High-Level Machine Vision Tools

New IMAQ Vision 6.0 for LabVIEW dramatically improves development productivity and simplifies vision software development. IMAQ Vision 6.0 addresses the challenge of configuring vision system applications for manufacturing. First, new high-level functions use edge detection and new region of interest (ROI) tools to extend visual inspection capabilities. For example, you can use edge detection to inspect automotive parts, electronic components, and fabricated metal. Edge detection is a common approach to measure or gauge dimension in an image. You may remember that the derivative locates inflection points for a continuous function. Many edge-detection algorithms use the second derivative of a line of pixel values in an image to locate edges. Once the edge locations are known, IMAQ Vision functions can calculate the distance between two edges. These new functions include edge detection tools for quickly finding edges along multiple search lines in rectangles, radii of a circle, and within concentric circles.

For example, using these new tools, you can quickly inspect the cross section of a fiber-optic cable. A fiber includes a core, which is surrounded by cladding. Important measurements include the diameter of the core and the circularity of the core. Using just two machine vision functions from IMAQ Vision 6.0, you can measure the diameter and center location of either the core or the cladding. With the new ROI tool, IMAQ Select Annulus, you can quickly draw or program a region bounded by two concentric circles. You draw this region so that it contains the perimeter of the circle to be measured. Another tool, IMAQ Find Edge Circular, then identifies points on the circular shape within the ROI, calculates a best fit circle for these points, and gives the diameter and center location as a result.

IMAQ Vision 6.0 now includes spatial calibration functions to make accurate measurements from images, regardless of camera angle or lens distortion.

Once IMAQ Vision has calculated the center of the core and cladding, you can easily measure core-cladding concentricity by using edge detection tools to measure the thickness of the cladding along several lines going through the center of the fiber. Plus, using the edge information, IMAQ Vision can measure core and cladding circularity. Other new functions include nondestructive overlay for displaying and manipulating graphics on acquired images without changing the underlying image data.



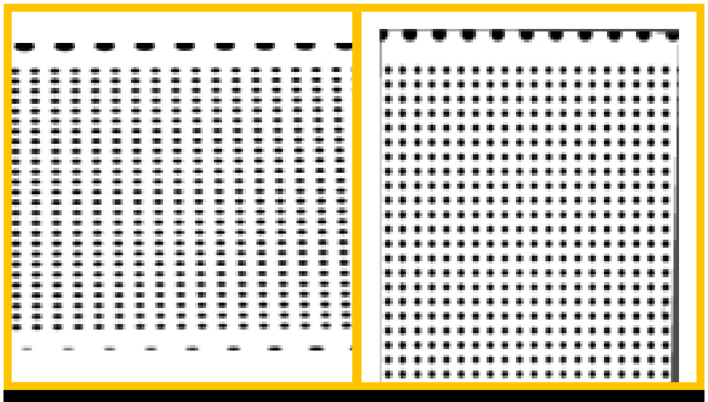
IMAQ Vision 6.0 features simplify edge detection measurements.

Measurement-Ready Images – Lens and Camera Angle Calibration

To make real-world measurements possible, IMAQ Vision 6.0 now includes spatial calibration functions to make accurate measurements from images, regardless of camera angle or lens distortion. Inspection applications often use relative pixel distances within the image to gauge manufacturing quality. If the distance in pixels is within preset tolerances, then the part is considered good. However, applications often require real-world units. Many factors go into gauging the actual length or width of an object in microns or millimeters. For example, if you wish to gauge an object, the position and angle of the camera are critical. Because of mechanical reasons, you often cannot place the camera perpendicular to the object. If the camera is tilted at an angle of 10 degrees, then the camera is not imaging an object in a flat field of view. Part of the object appears larger because it is closer to the lens.

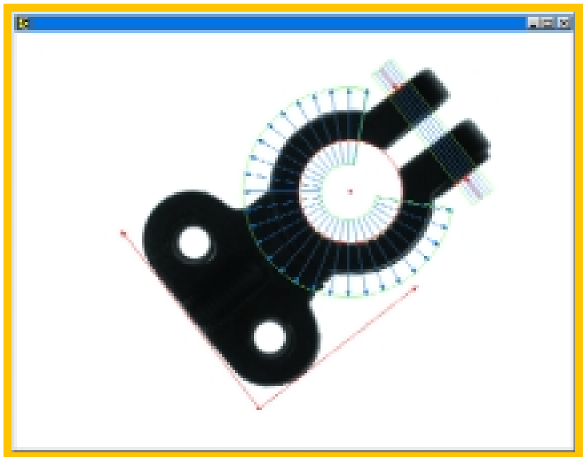
Also, lenses have nonlinear geometrical aberrations where the magnification changes in the field of view. Pixels at the center of the image have no distortion, while pixels at the perimeter of the image are distorted. These defects are virtually impossible to remove in the lens manufacturing process. Nonperpendicular camera and lens aberrations cause images to appear distorted. This distortion misplaces information in an image, but it does not necessarily destroy the information in the image.

To take advantage of spatial calibration functions to calibrate your imaging system,



New vision software accounts for camera angle and lens distortion.

you first define a calibration template consisting of circular dots, template pattern, laser grid pattern, or list of coordinates. The grid is a real-world template that provides constant spacing in the x and y directions. Using the grid and then selecting a calibration method, you can calibrate for camera angle and nonlinear lens errors. You can then map pixel coordinates to real-world units. Use this new measurement technique to improve the accuracy, consistency, and reliability of your inspection system.



New high-level functions simplify inspection.

Color Pattern Matching

Gray-scale pattern matching has been used for years as the standard tool for alignment and inspection applications. However, gray-scale images do not always have enough image information to distinguish objects quickly and accurately. When the only difference between objects is color, gray-scale pattern matching sometimes locates an object incorrectly. IMAQ Vision 6.0 offers fast and accurate pattern matching software for color inspection applications and challenging gray-scale applications. The color pattern matching software uses known reference patterns, or fiducials, in a color image. With color pattern matching, you create a model or template of an object. The search tool uses color information in the image to quickly locate matches, and then uses the shape information to obtain the precise location of the match. The function returns a match score based on the color and shape information. The score relates how closely the model matches the pattern found. You should use color pattern matching to locate reference patterns that are fully described by the color and spatial information in the pattern. Color can often simplify a monochrome problem by improving contrast or separation of the object from the background. Color pattern matching also has faster search times than gray-scale pattern matching in many applications when the object you are searching for has a distinct color.

Upgrade Now

Use IMAQ Vision 6.0 to simplify your machine vision software development. Whether you are a new or an experienced user, you can benefit from the ease of use and accuracy available with this software. To upgrade, visit ni.com/upgrade

John Hanks, Vision/Motion Product Manager
E-mail john.hanks@ni.com

For the IMAQ Vision Version 6.0 data sheet, visit ni.com/info and enter **newsletter**.

ni.com/vision

RTSI™ Makes Integration Simple and Effective

With a dedicated, high-speed digital bus, integrated solutions are easier than ever to build. Real-Time Systems Integration bus (RTSI) is a dedicated, high-speed digital bus that facilitates systems integration by low-level, high-speed, real-time communication between National Instruments measurement devices. RTSI capability comes standard with all National Instruments measurement devices.

Using the RTSI capability on a motion device, for example, you can share high-speed digital signals with data acquisition, image acquisition, or digital I/O products, with no external cabling and without consuming bandwidth on the host bus. The RTSI bus also has built-in switching, so you can route signals to and from the bus on-the-fly through software.

For PCI boards, the physical bus interface is an internal 34-pin connector; a ribbon cable inside the PC enclosure carries shared signals. RTSI cables are available for chaining two, three, four, or five boards together. PXI modules require no cabling because the built-in PXI trigger bus handles RTSI functions.

RTSI functionality varies depending on the board type. For example, on 7344 Series motion controller boards, you can directly read and write to the RTSI pins. With the newest release of NI-Motion™ software, you can map encoder pulses to a RTSI pin and also configure them as high-speed capture inputs or breakpoint outputs. You can use high-speed capture inputs as a trigger to capture and store position or initiate motion events. You can use breakpoint outputs to trigger other devices by asserting at preset positions. On E Series DAQ devices, 15 timing signals are available to RTSI, including timebase, acquisition clock, and general-purpose counter signals. On National Instruments image acquisition devices, a variety of trigger and video synchronization signals are available.

In summary, RTSI provides high-speed, hardware-based synchronization capability to any automated measurement or machine control application, and makes it easy for you to use National Instruments products to:

- Build high axis-count motion systems
- Clock data acquisition based on position
- Synchronize image acquisition with encoder pulses

For more information on RTSI, visit ni.com/info and enter **newsletter**.

ni.com/zone

Standardized Test Systems Improve Productivity and Cost

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businesses. Many companies recognize that standardizing their manufacturing processes can help them achieve this goal; however, they have difficulty determining where standardization efforts will yield the best results.

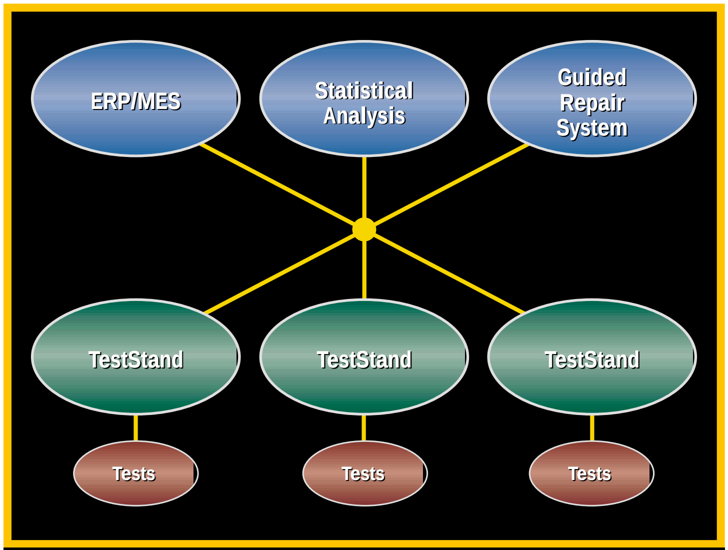
When determining standardization, you can assess three different levels of adoption. Companies that adopt the most rigid level risk noncompliance by some of their manufacturing groups. However, a standard that does not provide enough direction does not give you the benefit of minimized costs and maximized efficiency. Some companies have achieved success by standardizing their worldwide production at a test management platform level. This mid-level standardization is less inclusive than standardizing every software and hardware system in the manufacturing facility, making platform standardization one that the enterprise can more easily and readily embrace. Customers around the world use TestStand to standardize their test systems and achieve significantly lower test development and maintenance costs.

The Flexible Manufacturing Test Environment

In a manufacturing test environment, an application is required to provide a unified interface between the production control systems and business systems and the tests that run on each product or product family. This application is called a test executive. A test executive executes test routines, collects results, and passes data to other appropriate systems in the enterprise.

In the past, manufacturing test systems have often been developed around proprietary software written in-house to address the issues above. Today, more and more companies recognize the availability of commercial software to organize and manage their test systems. Using commercial software, you recognize enormous gains in productivity resulting in significant cost savings to the manufacturing organization.

To meet the needs of diverse manufacturing operations, however, commercially available test executives must be very flexible to connect to peripheral systems and adapt to new products and technologies.



Use TestStand to unify your test management strategy.

The Expense of Proprietary Software

Several years ago, manufacturing organizations faced few choices when it came to choosing a test executive system. For large organizations, developing an application flexible enough to use in different factories and on different product lines was a daunting task, often consuming several man-years of development for the initial test executive development.

The cost of developing such software, however, is only a small part of the total expense. All software requires maintenance as you upgrade and change systems, new operating systems come out, users request new features, and software suppliers need to fix software bugs. Maintenance of these systems often requires several full-time software engineers, costing the organization several hundred thousand dollars each year.

Also, you must train the engineers and assess risk if these key engineers are reassigned.

Building on a Commercial Framework

Building on commercial software platforms is even more important in today's rapidly changing markets. Product lifecycles have continued to shorten, margins have shrunk, and competition is tougher than ever. Successful manufacturing companies view manufacturing test as a strategic area and leverage commercial technologies to make it a key competitive advantage.

Commercially available software offers tremendous cost savings for manufacturing organizations. By leveraging economies of scale, software vendors can amortize their development costs over a large number of users and deliver powerful software at a low cost. Maintenance costs are reduced because the software vendor is responsible for bug fixes, new features, and porting to new operating systems. With National Instruments software, you can also take advantage of a large group of users and expert integrators, free technical support, widely available training courses, start-up assistance, and the availability of third-party add-on products. All these factors make you more productive and lower your overall costs because you can concentrate on your core functions of designing, manufacturing, and testing products.

Where Should You Standardize?

When businesses attempt to develop standards that are too rigid, they risk noncompliance by some of their manufacturing sites or product groups. Also, rigid standardization may fail to recognize and use the unique economic factors and competencies of the different production sites and product groups.

Conversely, a standard that does not provide enough direction also does not minimize costs and maximize efficiency. Without some standardization, disparate solutions tend to drift apart and interoperability of these systems becomes more difficult over time.

There are many different software applications in a manufacturing facility, from business systems, such as Manufacturing Execution Systems (MES), Engineering Resource Planning (ERP) systems, and corporate databases, to driver-level software used to communicate with hardware on the manufacturing line or test system. Some of

With TestStand, you can interface to test code written in almost any test development environment, and share that code around the world.

these systems are shown here. While it is beneficial and often necessary to standardize some of these systems on a regional or worldwide basis, other applications are obviously confined only to a specific factory or product family. Many manufacturing organizations wrestle with the issue of at what level to standardize their efforts. The answer to this question depends on many different things, including the nature of your product and production process, the size and geographical distribution of your manufacturing, and the existence of established systems.

For many organizations, following a "copy-exactly" or "factory-in-a-box" methodology, where each factory is an exact replica of all others, is unrealistic. Variations in labor costs, training levels, and existing systems in different factories provide slightly different manufacturing landscapes for each factory. The advantages of having common business systems and corporate databases across sites, though, are apparent; suppliers and internal customers around the world use these same systems. Further, other systems, such as Web-based b-to-b, part inventories, and others, depend on a common interface to extract information about each site.

The benefits of a common test software architecture are sometimes not as apparent. Most companies manufacture a number of different products. Each product has a unique set of test requirements and is often developed within its own product team. To be sure, there is some overlap in testing requirements, especially in collecting data from tests and interfacing to the other systems in the manufacturing line. It is in this interface that a common test executive has so much value. Without this common framework, each product test must redevelop its own native interface to all the other manufacturing systems, costing the company countless hours in unnecessary development effort.

Finally, standardizing software below the level of test executive is often difficult in a large organization. Different sites and product groups have different backgrounds and programming preferences, and varying levels of automation in different geographic locations may dictate different choices in hardware and product handling systems.

Flexibility to Meet Your Requirements

The benefits of standardizing test methodologies and systems are clear. The potential drawback to such standards, however, is that they provide such a rigid set of requirements that the individual sites cannot implement features that are essential to their success and efficiency. It is important, though, that any commercially available package has the flexibility to meet requirements that may be very specific to your unique manufacturing application.

TestStand provides a test executive framework with the flexibility to meet your specific manufacturing requirements. Because different groups of test engineers or product specialists have different programming backgrounds and preferences, with TestStand you can interface to test code written in almost any test development environment, including LabVIEW, Measurement Studio, Visual C++, Visual Basic, and many others. This flexibility is also important when displacing legacy systems.

With TestStand, you can preserve your investment by interfacing to existing test code, while beginning new development on modern test development environments for increased productivity and performance. TestStand also provides the flexibility to interface to your other manufacturing systems, business systems, and corporate databases. It provides a uniform interface from your test programs to the rest of the manufacturing organization.

This flexibility also means TestStand can provide a scalable architecture that you can use in applications ranging from small manufacturing and design verification applications to test systems for large, worldwide manufacturing organizations. TestStand can scale from test systems with very little automation to highly automated, high-speed testers.

Increasingly, companies are seeking to standardize manufacturing test systems and are looking for viable commercial software offerings to lower their costs and increase their productivity. Hundreds of companies have successfully standardized manufacturing test systems on TestStand and realized cost savings ranging from hundreds of thousands to even millions of dollars. By concentrating your efforts on core competencies and using standard, off-the-shelf software, you can lower your overall costs and make manufacturing test a key competitive advantage.

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To download the TestStand Style Guide app note, visit ni.com/info and enter **newsletter**.

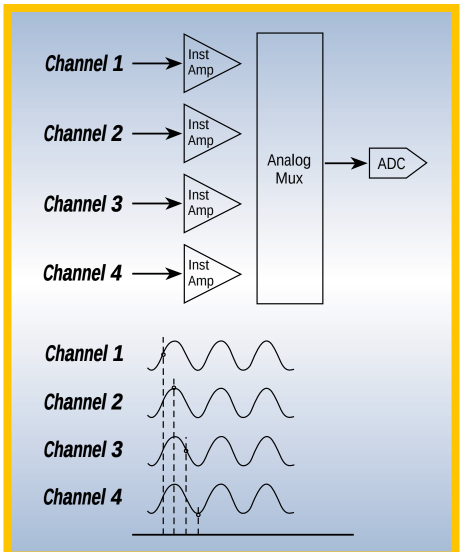
ni.com/teststand

Multiplexed or Simultaneous-Sampling Architecture for DAQ

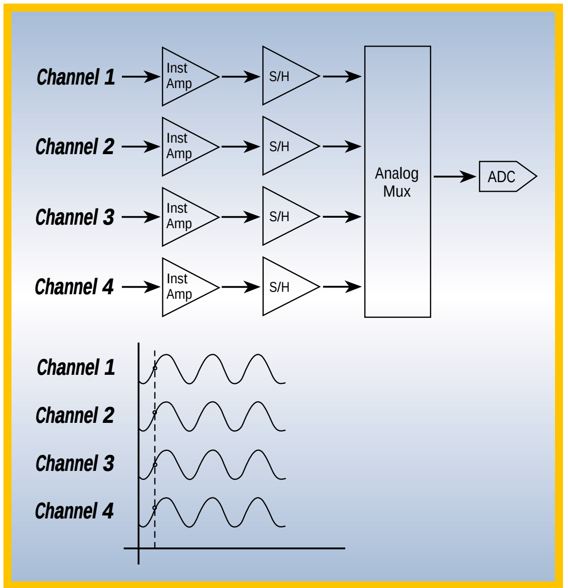
When selecting DAQ hardware to power your applications, you have a growing abundance of devices from which to choose.

After you find devices with enough speed and accuracy to digitize your signals, you still have to decide which analog architecture best serves your application needs. Analog architecture is fundamental to your DAQ system performance because it governs the accuracy of your measurements, the tradeoff of AC versus DC performance, the dynamic range of your system, the phase relationship between measured channels, and the I/O characterization of your entire system. The obvious and subtle technical differences between the two fundamental analog architectures, namely simultaneous sampling and multiplexing, complicate the selection process. If you invest time to select the right DAQ architecture for your system, you reap the benefit of improved system performance. Here we discuss how to evaluate the technical tradeoffs between simultaneous sampling and multiplexed DAQ devices as they apply to your applications. We use analog input operations to explain our system choices – the issues presented are identical for analog output operations.

The majority of DAQ devices on the market today are based on a multiplexed architecture. This architecture involves using a single analog-to-digital converter (ADC) to take measurements on several analog input channels by using a multiplexer to switch between them. Employing a multiplexer gives you a cost-effective way to achieve high-channel counts. Because of the round-robin sampling employed in multiplexed devices, each channel is sampled with a single sample delay between consecutive channels.



Multiplexed, Round-Robin Sampling
3 ms (54° phase shift) between Ch 1 and 4



Sample-and-Hold Simultaneous Sampling
3 ns (0.054° phase shift) between Ch 1 and 4

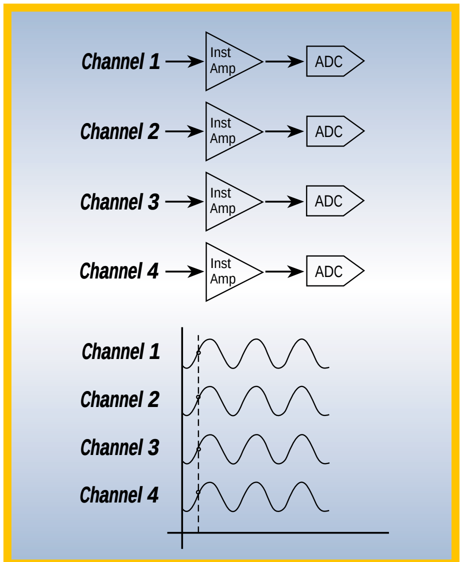
Multiplexed System Performance

To examine the performance of a multiplexed system, we use the example of four synchronous 50 kHz sine waves recorded by four analog input channels sampled at a rate of 1 MS/s. The digitizing process generates a time delay of 3 dt/1M (dt is the sampling interval of 1 µS), 3 µS, between samples on the first and fourth channel. The corresponding phase shift is 54 degrees, in this case between the first and fourth channels. If we increase the number of input channels to 31, our time delay increases to 30 µS and our phase shift is now at 540 degrees between Channels 1 and 31. Imagine we are monitoring the operation of 31 printed circuit boards with these 31 channels. Each channel corresponds to a different circuit board, so there is no interdependence between the channels.

In this scenario with decoupled channels, time or phase delay is often insignificant. Choosing a multiplexed DAQ device to solve this type of application is efficient and cost-effective.

Sample-and-Hold Performance

To increase the complexity of the example, we generate a stimulus for our circuit boards on an analog output channel and subsequently record the stimulus responses on our analog input channels. We use a hardware trigger to start the acquisition process as soon as the stimulus is generated. The problem is, now that our 31 channels respond to the same stimulus, they are coupled. In this example, Channel 31 is measuring the stimulus response 30 µS after the impulse has occurred. In a characterization process such as this one, the time delay can result in unexpected behavior, making a multiplexed architecture a dubious choice. Nevertheless, imagine trying to solve this application with a DAQ device that uses simultaneous sampling with a separate ADC per channel. It would have to employ 31 ADCs on the



ADC per Channel, True Simultaneous Sampling
1-2 ns (0.027 to 0.054° phase shift) between Ch 1 and 4

DAQ hardware to solve the application. A good alternative for high-channel count simultaneous-sampling applications is a sample-and-hold architecture that holds the analog input channel voltages at the exact same time, and then uses a multiplexer to digitize through the values. Sample-and-hold simultaneous sampling can minimize sampling delays between channels on the order of a few nanoseconds, helping you maintain the cost-effectiveness of multiplexing multiple channels through a single ADC and still avoid the relative time and phase delays associated with pure multiplexing.

Simultaneous-Sampling Solution

While sample-and-hold can be an effective way of performing simultaneous sampling, it does place a delay – the delay it takes to hold, multiplex, and digitize all your signals – in your input path. The delay makes sample-and-hold simultaneous sampling detrimental to high-speed single point control operations because of the induced loss of phase. This loss of phase also complicates characterizing a system that includes the DAQ device as a component. For high-speed analog input operations, minimizing the components in your analog input path provides the cleanest solution. The most flexible and powerful architecture available for high-end applications is true simultaneous sampling with a separate ADC per channel. By having a dedicated ADC for each of your analog input channels, you can control the timing, triggering, and digitizing independently.

Multiplexing is an effective way for high-channel count applications where you can tolerate relative time and phase delay between the different channels. Sample-and-hold simultaneous sampling cancels this delay, but it adds a delay in your input path and can contribute to phase loss in a high-speed characterization or control system. True simultaneous sampling with a separate ADC per channel is highly flexible and gives you channel independence at a higher price point. Whatever your application, you can analyze the effect of time and phase delays coming from your DAQ hardware and choose the right DAQ architecture to meet your specifications, while receiving the most appealing price-point per channel.

For more information on simultaneous sampling, visit ni.com/info and enter **newsletter**.

ni.com/zone

SCXI™ Module Designed for Accurate Strain Measurements

In applications where it is important to understand how an object reacts to various forces, strain gauge measurement systems are a common solution. A strain gauge is typically mounted to an object, such as an airplane wing, and produces an electrical signal when the object is subject to external forces. To read the signal from a strain gauge, your measurement instrumentation must provide basic signal conditioning functionality, including bridge completion, excitation, and amplification. Applications may require additional features, such as remote sensing and shunt calibration, for improved measurement accuracy. The new SCXI-1520 Universal Strain Gauge Module offers all these features in a single module.

The SCXI-1520 Universal Strain Gauge Module is designed for complex bridge-based transducers. The strain gauge module is compatible with quarter, half, and full-bridge strain gauges (120 and 350 Ω) and offers bridge completion circuitry for up to eight channels. The gain, filtering, and excitation setting for each channel is programmable through software commands. This feature greatly simplifies system configuration and application development because you do not have to open the module and adjust jumpers and potentiometers. In addition, with programmable excitation, you can easily adjust the excitation to the optimum voltage without heating your strain gauge. Each excitation channel of the SCXI-1520 also incorporates remote sensing circuitry to compensate for voltage drops due to lead resistance, thus improving the accuracy of your measurement. You can also use remote sensing to detect open or fault situations.

In high-channel count strain measurement systems, as well as systems with fast-changing input signals, it is often important to digitize simultaneous events with negligible skew time between channels to preserve the time relationship between channels. With a track-and-hold circuitry included on the SCXI-1520, you can simultaneously sample each channel.

You must have proper calibration to make accurate strain measurements. Each input channel of the SCXI-1520 has two independent shunt calibration circuits. With these shunts, you can simulate two known independent strain inputs and calibrate your measurement system to remove gain error and improve your overall accuracy. You can programmatically engage or disengage the shunt circuitry.

Your solution is the SCXI-1520 Universal Strain Gauge Module installed in your PXI system.

The SCXI-1520 Universal Strain Gauge Module is just one of the modules available in the SCXI signal conditioning product line. With more than 30 modules available for many different signal types, SCXI integrates all the measurement-ready technologies you demand into a single signal conditioning platform.

For the SCXI-1520 data sheet, visit ni.com/info and enter **newsletter**.

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Advances in Software – Measurement Services

Measurement services are a critical component of computer and network-based measurement solutions. They are the software you use to interface your programming environment, such as National Instruments LabVIEW and Measurement Studio or Microsoft Visual Basic, to your measurement hardware. Measurement & Automation Explorer and NI-DAQ™ are components of the National Instruments Measurement Services. With some of the recent advances in both components, you can create more sophisticated and higher-performance measurement and control applications. This new level of "measurement intelligence" increases your development productivity.

Instant Results with Measurement Intelligence

NI-DAQ 6.8, Measurement & Automation Explorer 2.0, and LabVIEW 6*i* offer measurement intelligence – the tight integration of measurement hardware with software to simplify configuration and improve measurement functionality. Measurement intelligence includes increased hardware support, simplified measurement and device configuration, and a new waveform data format that ties these data acquisition components with other elements of your program – data analysis and presentation.

Waveform Data Type Speeds Development

At the heart of measurement intelligence is a new waveform data format that contains information about the measurement, in addition to the acquired data. By standardizing on the waveform data type, data acquisition, measurement, mathematics, file I/O, and visualization functions connect quickly to produce immediate results – accelerating development by reducing the amount of code you need to write and simplifying the data flow between functions. Data acquisition functions acquire data that numerous analysis functions can immediately process. After performing acquisition and analysis, new functions (VIs) log waveforms directly to spreadsheet files or display these signals in full-featured graphs or tables.

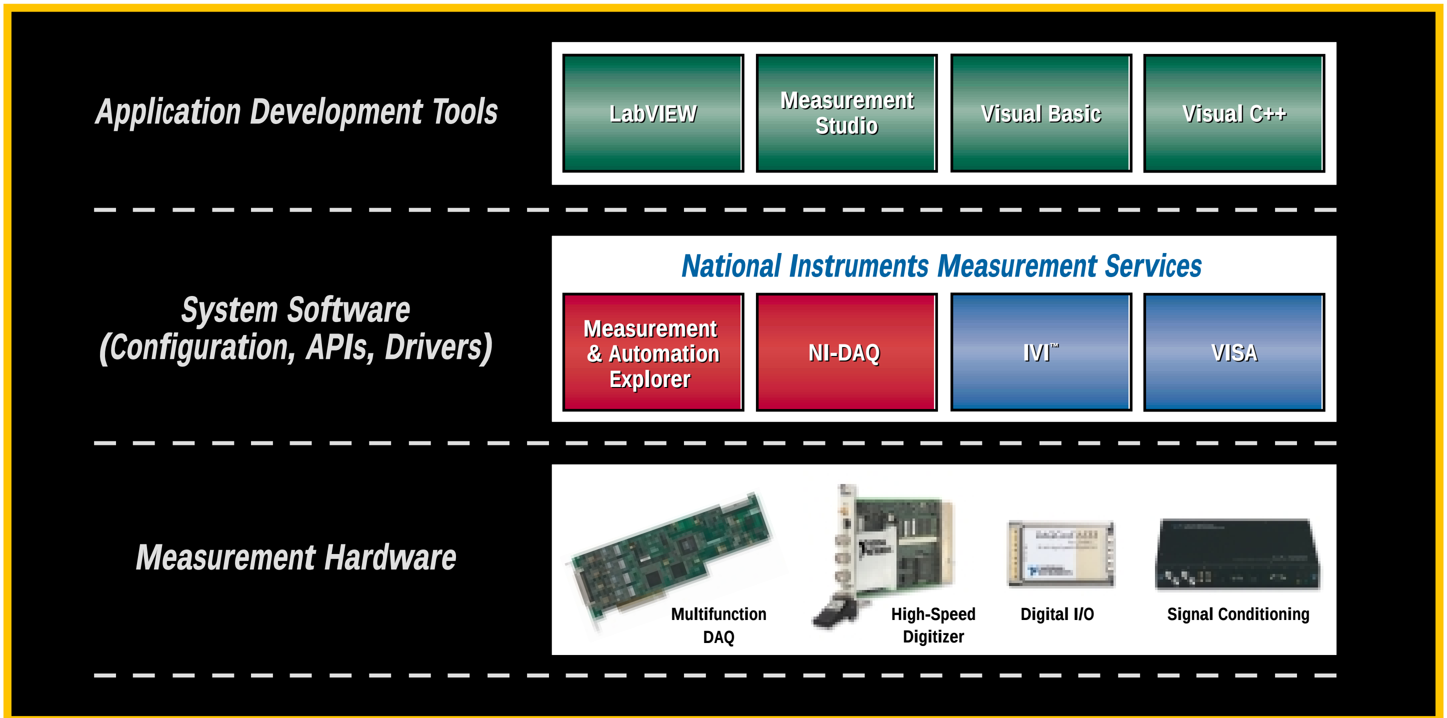
Acquire and Report Using Engineering Units

DAQ systems are often built to monitor temperature, displacement, and acceleration, in addition to electrical phenomena, such as voltages and currents. One traditional challenge in DAQ systems is conversion from the electrical units delivered by the DAQ hardware to the engineering units required by the user. With NI-DAQ, you can now replace tedious handwritten conversion functions with easy-to-use configuration panels available from Measurement & Automation Explorer. You can access these configured transducer channels through the new LabVIEW 6*i* DAQ Channel Name I/O control. This I/O control provides a quick and easy reference to the channels in your system. NI-DAQ performs scaling to engineering units using information about the measurement you entered into the configuration panels in Measurement & Automation Explorer.

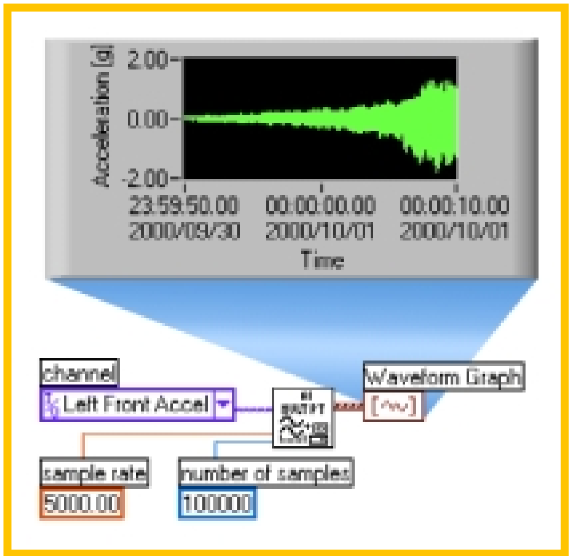
Improved Execution Speed

When developing measurement and automation applications, execution performance affects how quickly you can test products on a manufacturing line or how many experiments you can conduct in a day. Increased performance equals increased productivity.

Driven by many new stringent performance requirements, the latest versions of NI-DAQ



Measurement & Automation Explorer and NI-DAQ are components of the National Instruments Measurement Services.



Waveform data type accelerates application development.

dramatically improve its execution speed in areas, including:

- Single point analog input – 15 to 50 percent faster
- PID control loops – 25 percent faster
- Speed of scaling for transducer channels configured with Measurement & Automation Explorer – 33 to 94 percent faster
- Load time of NI-DAQ VIs in LabVIEW – 90 percent faster

Delivering Measurement Intelligence and Performance

The Measurement Services software has recently made strides in measurement intelligence and performance, so you can create measurement systems faster and more efficiently than ever.

Measurement intelligence encompasses many features that enhance your productivity, so you can concentrate on your end business or research goals – not on the mechanics of taking measurements.

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For more information on NI-DAQ, visit ni.com/info and enter **newsletter**.

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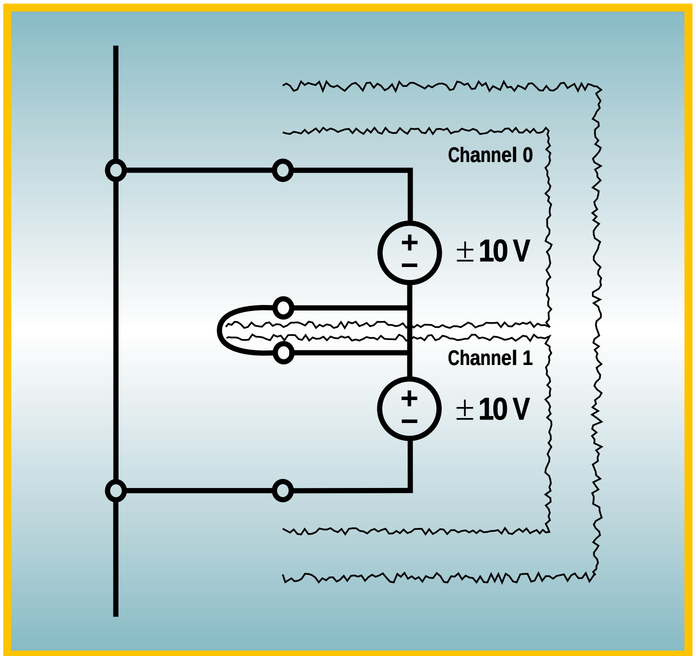
Tech Tip – Generating Voltage Signals above ±10 V

National Instruments offers a variety of products for reading higher voltage analog input signals, now up to ±1,000 V. However, you may need to generate a signal above ±10 V. If so, you can use the SCXI-1124 Isolated Analog Output Module. With this single module, you can generate signals up to ±60 V.

The SCXI-1124 is a six-channel isolated voltage/current output module. In voltage mode, each channel can generate up to 20 V (±10 V in a bipolar configuration). However, the notable technology is the independently isolated channels, meaning each output channel operates like an independent voltage source, such as a battery, except it is programmable. The benefit for you is you can "stack" analog output channels together to create even larger voltage signals.

The figure illustrates the channel configuration. Each channel of the SCXI-1124 can generate ±10 V. So, the maximum voltage output available across any channel is ±10 V. By "stacking" channels together, the maximum voltage across two consecutive channels is ±20 V. You can apply this same concept across multiple channels, or even multiple modules, to generate up to 250 V.

There are two issues of which to be aware when implementing a higher voltage output solution with the SCXI-1124. First, for the software, you still interact with each channel independently. In the example configuration shown here, if you want to generate an 18 V signal, you output 10 V on Channel 0 and 8 V on Channel 1. Second, while your voltage output capability increases by adding more channels, your current output capability does not. Each channel of the SCXI-1124 can supply/sink 5 mA when configured in voltage mode. Regardless of the number of voltage output channels you tie together, the maximum current available is still only ±5 mA.



Read higher voltage analog input signals with the SCXI-1124 – the channel configuration is shown here.

For more information on SCXI, visit ni.com/info and enter **newsletter**.

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