

Streamline Development of Instrument Control and Interface Applications Using LabVIEW 7 Express

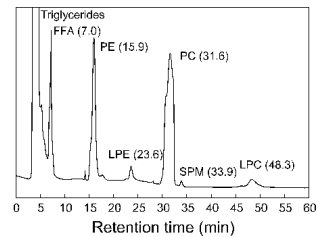
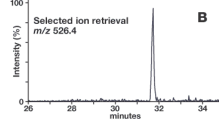
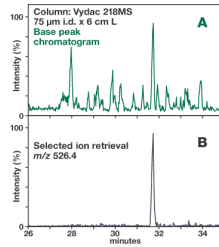
Shelley Gretlein
Software Group Manager
National Instruments

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As instrument complexities continue to grow, the vendor-defined executable shipped 'free' with your instrument is no longer sufficient. You need a software tool that delivers the power and flexibility to solve today's sophisticated analytical quandaries - however, you also need the ease-of-use associated with the ready-to-run software you are accustomed to. LabVIEW 7 Express delivers the tools you need to develop powerful applications quickly and easily. LabVIEW 7 Express delivers all of the power of a complete development environment – presented in a graphical, flow-chart manner to the most rapid application development available today.

Many Instruments, Many Data Types

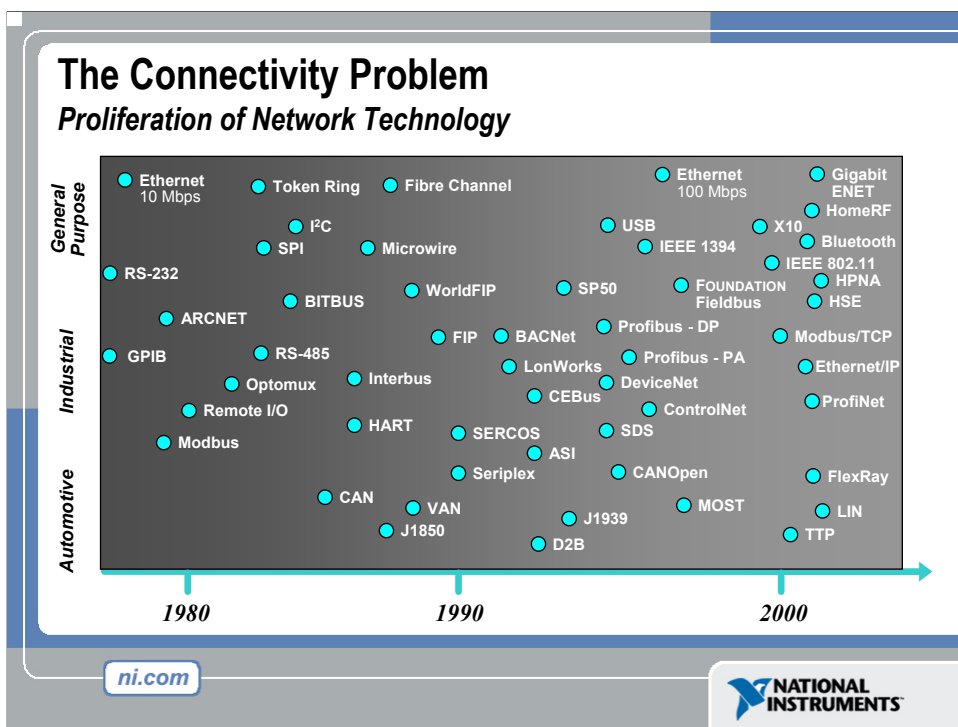


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In a typical laboratory environment you have multiple devices or instruments. Here are just a couple of examples such as scales and balances, mass spectrometers, and liquid chromatographs. Every device returns a different type of result <CLICK> with its own units, representation, and ranges. Your job consists of combining and interpreting the different results.

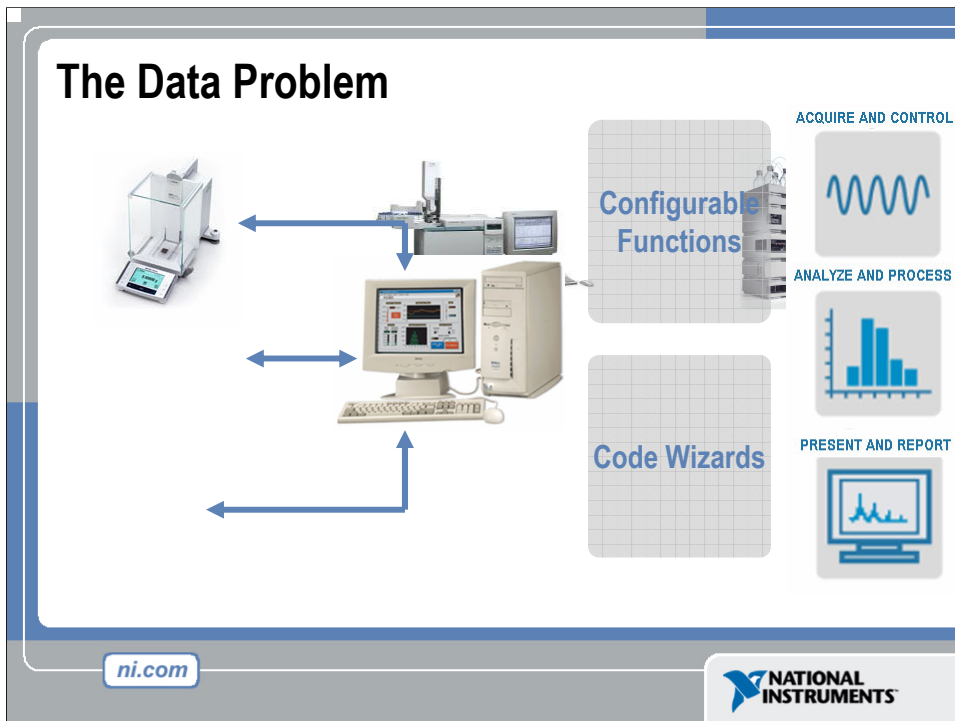
Some experiments require use of only one device, but many require multiple interactions and combining data from several devices. Other experiments require automating the devices for repeatability.



Another advantage of GPIB is its stability and consistency over the last 25 years. The chart above gives you a sense of the number of available network technologies. We divide them into a three different classes: automotive, industrial, and general purpose.

In the general purpose class you see buses such as Ethernet (10 Megabit, 100 Megabit, and Gigabit), USB, FireWire, and 802.11 Wi-Fi. Industrial buses include GPIB and other buses such as LonWorks for HVAC systems, Profibus used for Factory Automation, and ModBus.

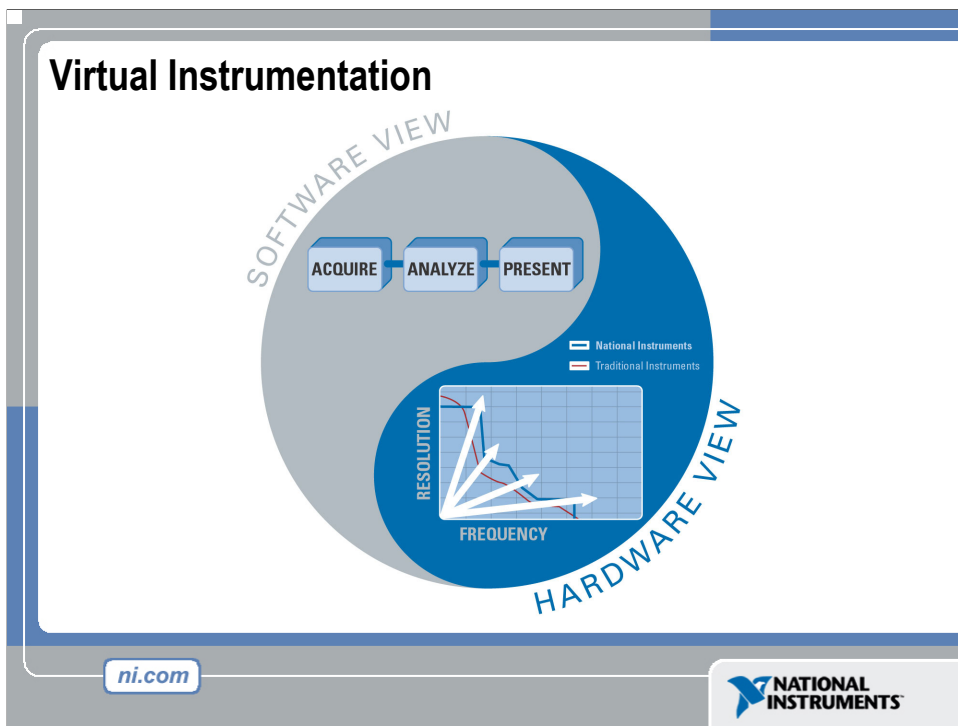
The continually changing landscape of general purpose buses makes them difficult to adapt to instrument control. Instruments and instrument control systems do not change as often as these network technologies. The key to shielding you from these changes is in providing links to these new buses and a software architecture that makes the choice of bus transparent.



Virtual Instrumentation – which consists of the combination of custom application software and a standard off-the-shelf PC – offers the ideal way of automating and retrieving data from your instruments.

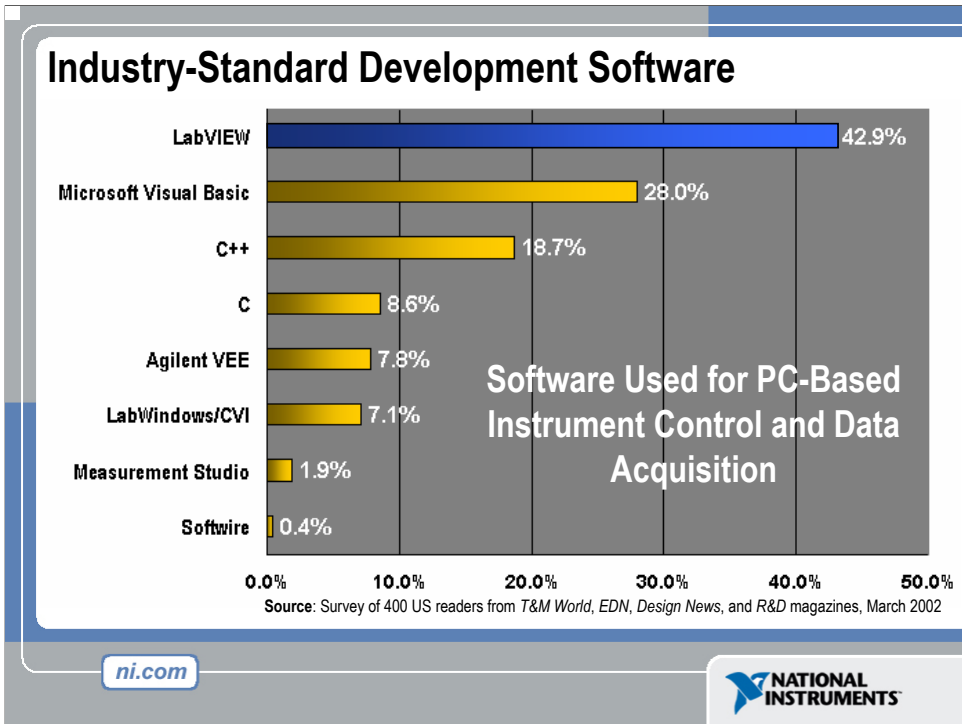
Now, traditional programming languages such as C++ or Visual Basic allow you to do pretty much anything you want, but it takes time to learn the ins and outs of text-based programming. On the other hand, you can use the software provided with the instruments to get your results, but then you're limited to what the manufacturer offers in terms of functionality.

<CLICK> With LabVIEW, you have both - the power of a programming language, and the ease of use of an application. With configurable functions and code wizards, you can create custom applications to acquire data, control your instruments, analyze and process your data, and present your results.



To summarize our discussion of virtual instrumentation, let's take a look at this image. The yin and the yang represent at the highest level, the relationship between the primary elements of virtual instrumentation: software and hardware. The flexibility of software, combined with powerful modular hardware solutions, creates the ultimate in flexible and scalable instrumentation systems. Because virtual instrumentation takes advantage of the advances of software and hardware, it can keep pace with technology, making your instrumentation systems the most flexible and most powerful. In particular, NI LabVIEW packages the power of a traditional programming language in an easy to use graphical development environment to increase your efficiency and reduce overall development time and cost.

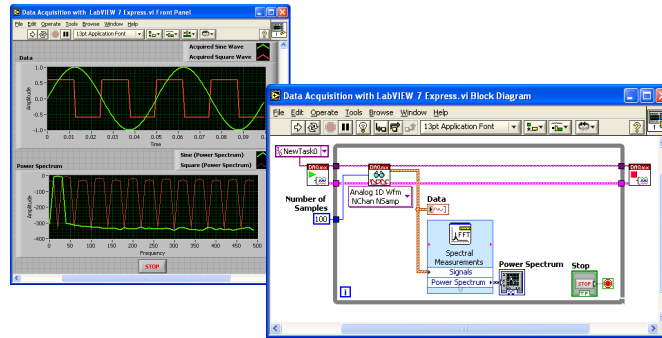
To further explain this concept, we take a look at a video on virtual instrumentation.



Today, we focus on graphical application development with the widely adopted NI LabVIEW. As you can see here, LabVIEW is the overwhelming leader in application software used in PC-based data acquisition and instrument control. This brings us to the next area of discussion in today’s seminar—What exactly *is* NI LabVIEW?

LabVIEW 7 Express

- Graphical Development Environment
- Optimized for Scientists
- Delivers productivity for acquisition, analysis, and presentation



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But what is LabVIEW - National Instruments LabVIEW is graphical development environment, where instead of using text to define your applications, you drag and drop blocks (or VIs as we call them) onto a diagram, configure their functionality by selecting options, and then wire them together to define the flow of the program. In fact, it's as easy as drawing a flow chart.

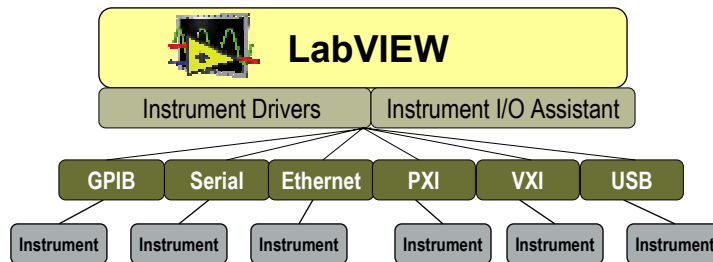
But enough talk – let's build an application from scratch. You can see we have a <instrument> here. We will create an app that send a command to the <instrument> telling it to <action>. Then, the our app will read the data back from it, perform <analysis> on the data, and present the results in the user interface.

Instrument Control with LabVIEW

LabVIEW can communicate with virtually any instrument

- Instrument drivers
- Instrument I/O Assistant

Tools for parsing, analyzing, and presenting instrument data



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LabVIEW is ideal for acquiring, analyzing, and presenting data—regardless of whether that data is acquired from a traditional instrument or a data acquisition board. LabVIEW provides tools to integrate with a wide range of instrument control buses, including GPIB, Serial, PXI, Ethernet, and VXI. After acquiring the raw data, LabVIEW has the tools for parsing, analyzing, and presenting the data.

In addition to providing direct I/O support for just about any instrument that supports a programmatic interface, National Instruments has more than 1,400 instrument drivers. An instrument driver is a LabVIEW VI library that contains high-level VIs that allow you to control a specific instrument or family of instruments. You do not need to use an instrument driver to communicate to an instrument in LabVIEW. Some reasons why you would not use an instrument driver include:

- You only need to send a few commands to your instrument.
- A pre-existing driver does not exist.
- You do not need to distribute a set of commands to others.

Since LabVIEW and NI-supported device drivers are platform independent, your instrument control code that works on one platform can easily be ported to other operating systems.

For example, you can share instrument control code between a Microsoft Windows-based system and a Macintosh operating system.

Instrument Drivers

Set of software routines to control a programmable instrument

Simplify instrument control

Reduce user development time

- Eliminates need to learn new programming protocol
- Common architecture and interface

Use common architecture

- Increase performance
- Increase portability

Use intuitive controls/indicators

- No string formatting needed
- No string parsing needed

Instrument Driver Network – ni.com/idnet

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Although VISA simplifies instrument control programming significantly, it still requires

low-level knowledge of instrument communication and of instrument command sets. As an improvement, instrument and software vendors began writing instrument drivers. Instrument drivers are a set of high-level software routines to control a programmable instrument. For example, instead of sending four commands to an oscilloscope to set it up to perform an acquisition, an instrument driver would have one function call that configures the scope.

Instrument drivers simplify instrument control and significantly reduce the amount of time required to develop an instrument control application. Not only do instrument drivers eliminate the need for the user to learn new command sets for each instrument, but they also provide a common architecture and interface to the user.

Intuitive high-level functions

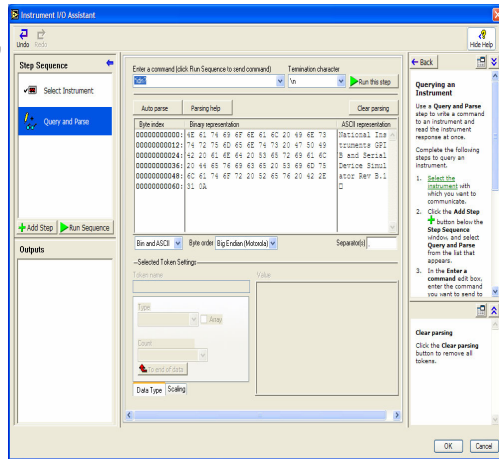
- Instrument addressing
- Command string building
- Range checking
- Memory storage
- Data scaling
- Response string parsing

Instrument I/O Assistant

I/O communication to Serial, GPIB, Ethernet, PXI, VXI, or USB instruments

Simplifies instrument control applications

- Reduces development time
- Little to no programming required
- Auto-parsing



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New to LabVIEW 7 Express is the Instrument I/O Assistant VI, which makes instrument control easier than ever before. You can communicate directly with any Serial, GPIB, PXI, VXI, USB, or Ethernet instrument through a user interface that allows for little to no programming. The Instrument I/O Assistant allows you to write commands to and read commands from your instrument as well as parse the instrument response data. You can interactively view instrument data returned from your instrument, which provides for simple troubleshooting and configuration. The auto-parse feature will automatically format your instrument data into LabVIEW data types, saving you time and effort. You also can reuse sequences of commands to your instrument by saving the Instrument I/O Assistant configuration as a VI and using it in another application.

All this significantly reduces development time and simplifies instrument control applications.

Integrated Demos at National Instruments Booth

- Automated Test Tube Inspection with LabVIEW, NI IMAQ/Vision and Motion Control
- Sample Handling using LabVIEW and Compact FieldPoint
- Automated pH Measurements with a PC
- Connect and Control Your Instrumentation with LabVIEW

- Automated MALDI-MS Data Acquisition Accurate laser beam
 - Applied Biosystems | MDS SCIEX
- Laboratory Information Management System (LIMS)
 - VI Engineering
- PDA-based Instrument Control
 - PVI Systems
- Laboratory Monitoring System (Plexxium)
 - Mack Information Systems

Please Visit NI @ Booth # 620

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Demos at the NI PittCon 2004 Booth:

Sample Handling using LabVIEW and Compact FieldPoint

Automated pH Measurements with a PC

Automated Test Tube Inspection with LabVIEW, NI IMAQ/Vision and Motion Control

Connect and Control Your Instrumentation with LabVIEW

Automated MALDI-MS Data Acquisition Accurate laser beam

Applied Biosystems | MDS SCIEX

Laboratory Information Management System (LIMS)

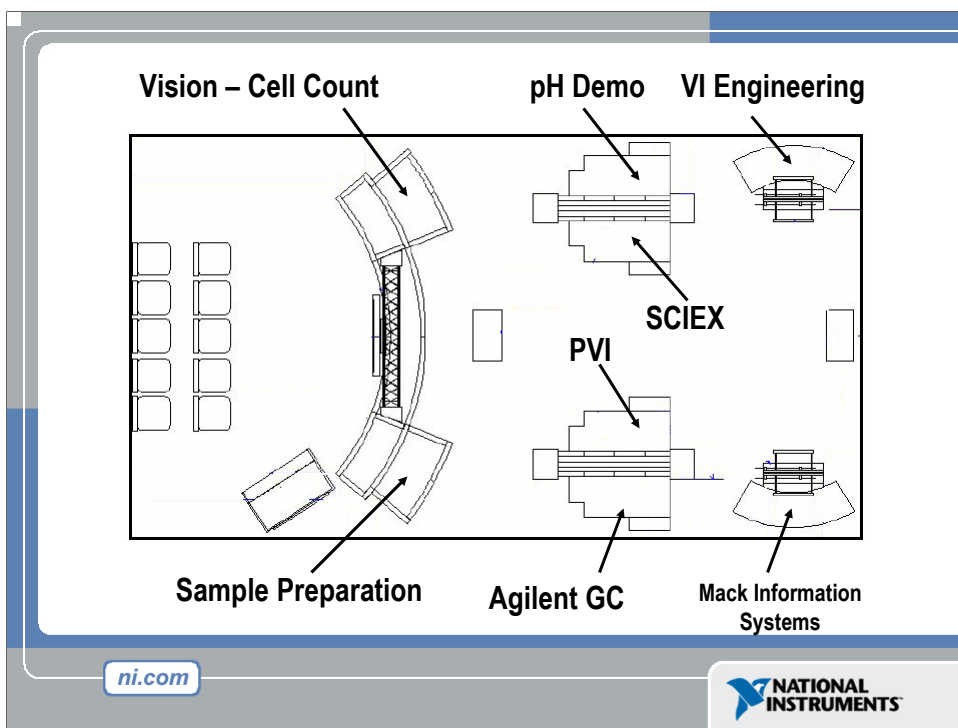
VI Engineering

PDA-based Instrument Control

PVI Systems

Laboratory Monitoring System (Plexxium)

Mack Information Systems



Pittcon 2004

National Instruments Demos

1) Sample Handling using LabVIEW and Compact FieldPoint

What problem are we solving:

Lab automation requires the handling of chemical entities based in fluids, powders, and other forms. We provide automation to handle and prepare the sample.

50 word description:

The Sample Handling demonstration uses National Instruments LabVIEW to control a Harvard Apparatus Syringe pump to drive fluid into four beakers. The CompactFieldpoint digital module turns on a series of heaters placed in each beaker to raise the temperature. Sensors in the beaker read the temperature and when the temperature setpoint is reached, LabVIEW turns off the heaters, opens a series of valves to drain the beaker one after the other. The Harvard Syringe pump then redraws the fluid from the retaining beaker back into the Syringe pump.

HW/SW used:

National Instruments LabVIEW and Compact Fieldpoint modules including temperature, PWM, Digital I/O, and Serial modules.

2) Automated pH Measurements with a PC

What problem are we solving:

The manual collection of pH measurements, manual data entry, and inaccuracy of litmus paper.

50 word description:

Traditionally, lab technicians and scientists use litmus paper or a handheld probe to take pH measurements. This is fine if you need a one-time estimate. However, for controlled experiments that require accuracy of the measurement and data integrity, a simple PC-based approach to taking measurements is preferred.

HW/SW used:

LabVIEW or VI Logger, Multifunction Data Acquisition (DAQ) device, any standard pH probe.

3) Automated MALDI-MS Data Acquisition

What problem are we solving:

Accurately align laser beam with sample spots in real-time.

50 word description:

The application of machine vision technology in MALDI-MS overcomes the difficulty of accurately aligning the laser beam with sample spots during an automated data acquisition run. It also generates laser search patterns tailored to the size of the given sample spots. This automation significantly increases the accuracy for high-throughput analysis.

HW/SW used:

LabVIEW, GPIB, Vision

Company: Applied Biosystems | MDS SCIEEX

4) Laboratory Monitoring System (Plexxium)

What problem we are solving:

Monitoring, Recording and Alarming per 21 CFR 11 in FDA regulated Laboratories and Processing Facilities

50 word description:

An easily validated TCP/IP compatible system for use in biologics, research, HVAC, hatcheries, greenhouses, fisheries and food processing. Cost-effective from one point to thousands. Seamless integration of up to 64 locations that in-turn allows access, acknowledgement, alarm notification via phone, email, and pager over the internet and local networks.

NI LabVIEW Built-In Analysis

Basic Analysis

1D Linear Evaluation
 1D Polynomial Evaluation
 2D Linear Evaluation
 2D Polynomial Evaluation
 A x B
 A x Vector
 Complex LU Inverse Matrix
 Determinant
 Dot Product
 Histogram
 Inverse Matrix
 Mean
 Median
 Mode
 Outer Product
 Real Compact Array to Matrix
 Real Compact Cho Inverse Matrix
 Real Compact Cholesky Factor
 Real Compact Tri-Matrix Inverse
 Real LU Factor
 Real LU Inverse Matrix
 Real Matrix to Compact Array
 Std Deviation and Variance

Measurements

AC & DC Estimator
 Amp & Freq Estimate
 Amplitude and Phase Spectrum
 Auto Power Spectrum
 Cross Power Spectrum
 Find Exact Peak
 H(f)
 Harmonic Analyzer
 Impulse Response Function
 Network Functions (avg)
 Power & Frequency Estimate
 Scaled Time Domain Window
 Signal Generator by Duration
 Spectrum Unit Conversion
 Transfer Function

Signal Generation

Arbitrary Wave
 Chirp Pattern
 Gaussian White Noise
 Impulse Pattern
 Periodic Random Noise
 Pulse Pattern
 Ramp Pattern

Sawtooth Wave
 Sinc Pattern
 Sine Pattern
 Sine Wave
 Square Wave
 Triangle Wave
 Uniform White Noise

Windowing

Blackman Window
 Blackman-Harris Window
 Cosine Tapered Window
 Cosine Window Coefficients
 Exact Blackman Window
 Exponential Window
 Flat Top Window
 Force Window
 General Cosine Window
 Hamming Window
 Hanning Window
 Kaiser-Bessel Window
 Triangle Window
 Window Parameters

Filters

Bessel Coefficients

Bessel Filter
 Butterworth Coefficients
 Butterworth Filter
 Cascade->Direct Coefficients
 Chebyshev Coefficients
 Chebyshev Filter
 Coercion for FIRNC
 Elliptic Coefficients
 Elliptic Filter
 Equi-Ripple BandPass
 Equi-Ripple BandStop
 Equi-Ripple HighPass
 Equi-Ripple LowPass
 FIR Coefficients
 FIR Filter
 FIR Narrowband Coefficients
 FIR Narrowband Filter
 FIR Windowed Coefficients
 FIR Windowed Filter
 IIR Cascade Filter with I.C.
 IIR Cascade Filter
 IIR Filter with I.C.
 IIR Filter
 Inv Chebyshev Coefficients

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Inverse Chebyshev Filter
 Median Filter
 Parks-McClellan
Statistics
 1D, 2D, and 3D ANOVA
 Chi Square Distribution
 Contingency Table
 erf(x)
 erfc(x)
 F Distribution
 General Histogram
 Inv Chi Square Distribution
 Inv F Distribution
 Inv Normal Distribution
 Inv T Distribution
 Moment about Mean
 MSE
 Normal Distribution
 Polynomial Interpolation
 Rational Interpolation
 RMS
 Spline Interpolant
 Spline Interpolation
 T Distribution
Signal Processing
 AutoCorrelation
 Complex FFT
 Convolution

Cross Power
 CrossCorrelation
 Decimate
 Deconvolution
 Derivative x(t)
 Fast Hilbert Transform
 FHT
 Integral x(t)
 Inverse Complex FFT
 Inverse Fast Hilbert Transform
 Inverse FHT
 Inverse Real FFT
 Power Spectrum
 Pulse Parameters
 Real FFT
 Unwrap Phase
 Y[j]=Clip{X[j]}
 Y[j]=X[j]-n
 Zero Padder
Curve Fitting
 Exponential Fit Coefficients
 Exponential Fit
 General LS Linear Fit
 General Polynomial Fit
 get new coefficients
 Lev-Mar abx
 Lev-Mar xx

Linear Fit Coefficients
 Linear Fit
 Nonlinear Lev-Mar Fit
 partial derivative
 Target Fnc & Deriv NonLin

Linear Algebra

Cholesky Factorization
 Complex A x B
 Complex A x Vector
 Complex Cholesky Factorization
 Complex Conjugate Transpose Matrix
 Complex Determinant
 Complex Dot Product
 Complex EigenValues and Vectors
 Complex Inverse Matrix
 Complex LU Factorization
 Complex Matrix Condition Number
 Complex Matrix Norm
 Complex Matrix Rank
 Complex Matrix Singular Values
 Complex Matrix Trace
 Complex Outer Product
 Complex Pseudoinverse Matrix
 Complex QR Factorization
 Complex SVD Factorization
 Create Special Complex Matrix

Create Special Matrix
 EigenValues and Vectors
 LU Factorization
 Matrix Condition Number
 Matrix Norm
 Matrix Rank
 Matrix Singular Values
 Pseudoinverse Matrix
 QR Factorization
 Solve Complex Linear Equations
 Solve Linear Equations
 SVD Factorization
 Test Complex Positive Definite
 Test Positive Definite
 Trace
Numeric Operations
 1D Polar To Rectangular
 1D Rectangular To Polar
 Complex Polynomial Roots
 Normalize Matrix
 Normalize Vector
 Numeric Integration
 Peak Detector
 Polar To Rectangular
 Quick Scale 1D
 Quick Scale 2D
 Rectangular To Polar

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Scale 1D	Limit	Differential Equations	Brent Search Powell
Scale 2D	Partial Derivative Prep	Cash Karp Check Prep	Brent with Derivatives 1D
Threshold Peak Detector	Partial Derivatives of $f(x_1, x_2)$	Cash Karp Check	Brent with Derivatives Prep
Unit Vector	Zeros and Extrema of $f(x)$	Cash Karp Function	Chebyshev Approximation Prep
1D and 2D Evaluation	Numeric Functions	Cash Karp General	Chebyshev Approximation
Curve Length Preparation	Bessel Function $J_0(x)$	Cash Karp Global	Conjugate Gradient Global
Curve Length	Bessel Function $J_1(x)$	Cash Karp Global0	Conjugate Gradient nD
Differentiation	Bessel Function $J_n(x)$	Euler Check Prep	Derivative Fletcher
Eval Polar to Rect Optimal Step	Bessel Function $Y_0(x)$	Euler Check	Downhill Simplex nD Global
Eval Polar to Rect	Bessel Function $Y_1(x)$	Euler Function	Downhill Simplex nD Inner Part
Eval X-Y(a,t)	Bessel Function $Y_n(x)$	Euler Global	Downhill Simplex nD Value
Eval X-Y(t) Optimal Step	Bessel Polynomial	Multiple Roots	Downhill Simplex nD
Eval X-Y(t)	Beta Function	ODE Cash Karp 5th Order	Find All Minima 1D
Eval $y=f(a,x)$	Binomial Coefficient	ODE Euler Method	Find All Minima nD Prep
Eval $y=f(x)$ Optimal Step	Carlson Elliptic Integral 1st Kind	ODE Linear nth Order Numeric	Find All Minima nD
Eval $y=f(x)$ Prep	Chebyshev Polynomial	ODE Linear nth Order Symbolic	Fitting on a Sphere
Eval $y=f(x)$ Prep1	Continued Fraction Complex	ODE Linear System Numeric	Function and Derivative
Eval $y=f(x)$ Prep2	Continued Fraction	ODE Linear System Symbolic	Function and Derivatives CG
Eval $y=f(x)$	Cosine Integral	ODE Runge Kutta 4th Order	Golden Section 1D
Eval X-Y-Z(a,t1,t2) Prep	Gamma Function	Runge Kutta Check Prep	Golden Section Inner Part
Eval X-Y-Z(a,t1,t2)	Incomplete Beta Function	Runge Kutta Check	Levenberg Marquardt P.D
Eval X-Y-Z(t1,t2)	Incomplete Gamma Function	Runge Kutta Function	Levenberg Marquardt Prep
Eval $y=f(a,x_1,x_2)$ Prep	Jacobian Elliptic Function	Runge Kutta Global	Levenberg Marquardt
Eval $y=f(a,x_1,x_2)$	Legendre Elliptic Integral 1st Kind	Transfer LSS Imaginary	Line Minimum Derivative
Eval $y=f(x_1,x_2)$ Prep	Sine Integral	Transfer LSS Real	Line Minimum Fletcher
Eval $y=f(x_1,x_2)$	Spike Function	Optimization	Linear Programming Middle
Extrema of $f(x_1,x_2)$	Square Function	Bracket Fletcher	Linear Programming Preparation
Integration	Step Function	Brent Search Powell Prep	Linear Programming Simplex Method

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LP Simplex Method Inner Part	Find String Identifier	Prime FFT	Nonlinear System Single Solution
Normalized Case Decode	Function Decomposition	Radix 2 Real	Nonlinear System Solver
Normalized Case	Left and Right Parts	Sparse FFT	Polynomial Real Zero Counter
One Step Normalized	List of Variables	Sparse Signal FFT	Ridders Zero Finder
Pade Approximation	Number Decomposition	STFT Calculation	Ridders Zero Inner Part
Reflection Point	Number Split	STFT Spectrogram	Sign Changes
Transport Problem to Linear	Operation Selection	Unevenly Sampled Signal Spectrum	Sturms Chain Single Roots
Programming	Parse Formula Node	Walsh Hadamard Inverse	Zero Deletion
Parser Functions	Parse Formula String	Walsh Hadamard	Zero Global
Atomic Check	Plus Minus Correction	Wavelet Transform Daubechies4	Point-by-Point Array Operations
Backward Bracket Search	Space Deletion	Inverse	1D Linear Evaluation PtByPt.vi
Backward Decompose Number	Split the String	Wavelet Transform Daubechies4	1D Polar to Rectangular PtByPt.vi
Backward Number Split	String Index	WVD Calculation	1D Polynomial Evaluation PtByPt.vi
Bracket Balancing	String to Tree Inner Part	WVD Spectrogram	1D Rectangular to Polar PtByPt.vi
Bracket Deletion	String to Tree Preparation	Zero Functions	Normalize Vector PtByPt.vi
Coded Eval Parsed Formula String	String to Tree	Division p(x) and q(x)	Quick Scale 1D PtByPt.vi
Compiler RPN	Substitute Variables	Find All Zeroes Inner Part	Scale 1D PtByPt.vi
Compiler Tree Structure	Three Register Calculation	Find All Zeroes of f(x)	Unit Vector PtByPt.vi
Dot or Comma	Type of a Substring	Formula Check	Point-by-Point Filters
Double Structure	x Decode	Function Values	Bessel Filter PtByPt
Eval Formula Node	Transfer Functions	GCD of p(x) and q(x)	Butterworth Filter PtByPt
Eval Formula String	Buneman Frequency Estimator	Line Search Prep	Chebyshev Filter PtByPt
Eval Multi-Variable Array	Class Generator	Line Search	Elliptic Filter PtByPt
Eval Multi-Variable Scalar	Daubechies4 Function	Multiple Zeroes	Equi-Ripple BandPass PtByPt
Eval Parsed Formula Node	Dual Signal FFT	Multiplication p(x) and q(x)	Equi-Ripple BandStop PtByPt
Eval Parsed Formula String	Fractional FFT	Newton Raphson Inner Part	Equi-Ripple HighPass PtByPt
Eval Single-Variable Array	Laplace Transform Real	Newton Raphson Zero Finder	Equi-Ripple LowPass PtByPt
Eval Single-Variable Scalar	Power Spectrum Fractional FFT	Nonlinear System Prep	FIR Filter PtByPt

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FIR Windowed Filter PtByPt
 IIR Cascade Filter PtByPt
 IIR Cascade Filter with I.C. PtByPt
 IIR Filter PtByPt
 IIR Filter with I.C. PtByPt
 Inverse Chebyshev Filter PtByPt
 Median Filter PtByPt
Point-by-Point Fitting
 Exponential Fit Coefficients PtByPt
 FIR Windowed Filter PtByPt
 IIR Cascade Filter PtByPt
 IIR Cascade Filter with I.C. PtByPt
 IIR Filter PtByPt
 IIR Filter with I.C. PtByPt
 Inverse Chebyshev Filter PtByPt
 Median Filter PtByPt
Point-by-Point Fitting
 Exponential Fit Coefficients PtByPt
 Exponential Fit PtByPt
 General LS Linear Fit PtByPt
 General Polynomial Fit PtByPt
 Linear Fit Coefficients PtByPt
 Linear Fit PtByPt
 Linear Intpolation
 Polynomial Interpolation PtByPt
 Rational Interpolation PtByPt
 Recurrence for Rational Interpolation

Spline Interpolant PtByPt
 Spline Interpolation PtByPt
Point-by-Point Frequency Domain
 Amplitude and Phase Spectrum PtByPt
 Auto Power Spectrum PtByPt
 Buneman Frequency Estimator PtByPt
 C2P_zero
 Complex FFT PtByPt
 Cross Power PtByPt
 Cross Power Spectrum PtByPt
 Fast Hilbert Transform PtByPt
 FHT PtByPt
 Impulse Response Function PtByPt
 Inverse Complex FFT PtByPt
 Inverse Fast Hilbert Transform PtByPt
 Inverse FHT PtByPt
 Inverse Real FFT PtByPt
 Power Spectrum PtByPt
 Real FFT PtByPt
 Round to Zero
 Single Side Real FFT PtByPt
 STFT Spectrogram PtByPt
 Transfer Function PtByPt
 Walsh Hadamard Inverse PtByPt
 Walsh Hadamard PtByPt
 Wavelet Transform Daubechies4 Inverse PtByPt
 Wavelet Transform Daubechies4 PtByPt

Windowed FFT PtByPt
 WVD Calculation
 WVD Spectrogram PtByPt
Point-by-Point Linear Algebra
 Complex Dot Product PtByPt
 Complex Outer Product PtByPt
 Dot Product PtByPt
 Outer Product PtByPt
Other Point-by-Point Functions
 Add Array Elements PtByPt
 Array Max & Min PtByPt
 BinarySearch
 Boolean Crossing PtByPt
 Complex Queue PtByPt
 Data Queue PtByPt
 Decrement PtByPt
 Increment PtByPt
 Search 1D Array PtByPt
 Sort 1D Array PtByPt
 Value Has Changed PtByPt
 Zero Crossing PtByPt
 Zero-Order Hold PtByPt
Point-by-Point Probability and Statistics
 General Histogram PtByPt
 Generate Bins
 Histogram by Bins
 Histogram PtByPt

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Mean PtByPt	Savitzky Golai Filter PtByPt
Median PtByPt	Threshold Peak Detector PtByPt
Mode PtByPt	Unwrap Phase PtByPt
Moment about Mean PtByPt	$Y[i]=\text{Clip}(X[i])$ PtByPt
MSE PtByPt	$Y[i]=X[i-n]$ PtByPt
RMS PtByPt	
Sample Variance PtByPt	
Standard Deviation PtByPt	
Variance PtByPt	
Point-By-Point Signal Generation	
Gaussian White Noise PtByPt	
Periodic Random Noise PtByPt	
Sawtooth Wave PtByPt	
Sine Wave PtByPt	
Square Wave PtByPt	
Triangle Wave PtByPt	
Uniform White Noise 2 Points	
Uniform White Noise PtByPt	
Point-by-Point Time Domain	
AC & DC Estimator PtByPt	
AutoCorrelation PtByPt	
Convolution PtByPt	
CrossCorrelation PtByPt	
Deconvolution PtByPt	
Derivative $x(t)$ PtByPt	
Integral $x(t)$ PtByPt	
Peak Detector PtByPt	

*For a complete list of analysis functions
in NI LabVIEW, go to ni.com/analysis.*

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Present Data with NI LabVIEW

Visualization

- Built-in user interface design objects
- Charting and graphing utilities
- Remote application viewing and control

Report Generation

- Documentation Tools
- HTML reports for the Web
- Microsoft Word and Excel reports
- Interactive report generation with NI DIAdem

Data Management & Connectivity

- NI DIAdem
- Database Connectivity Toolset
- File I/O
- NI DataSocket
- Open Environment (ActiveX, DLLs)
- Communication and Data Standards
 - TCP/IP
 - OPC
 - SQL database connectivity
 - XML data format

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Presentation of your data encompasses several different areas of functionality—visualization, report generation, and data management and connectivity. LabVIEW includes a wide array of visualization tools to make your data presentation attractive and simple to create. Some of these tools include charting and graphing utilities, and built-in 2D and 3D visualization tools. Attributes of your presentation such as color, font size, and graph type can be instantly reconfigured, and you can even rotate, zoom, and pan your graphs at run-time. Additionally, it is now possible to view and control your VIs over the Internet using a tool called Remote Panels, which we will discuss in more detail on the following slide.

In terms of report generation, National Instruments offers several options, including documentation-generation tools, HTML reports, programmatic generation of Microsoft Word and Excel reports, and interactive report generation with NI DIAdem.

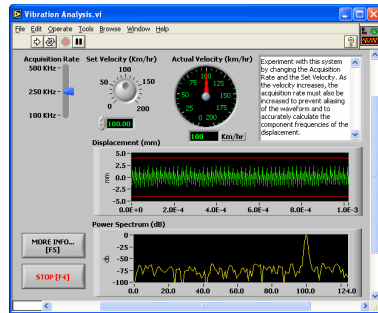
Finally, we must consider data management and connectivity. NI DIAdem offers data management and offline analysis for large data sets, tools such as the Database Connectivity Toolset allow you to connect to third-party databases, and standard File I/O makes saving your data easier than ever. In terms of connectivity, LabVIEW offers simple ways to incorporate ActiveX software, dynamic link libraries (DLLs), and shared libraries from other tools. In addition, you can share LabVIEW code as a DLL, built executable, or using ActiveX.

LabVIEW also offers a full range of options for communications and data standards, such

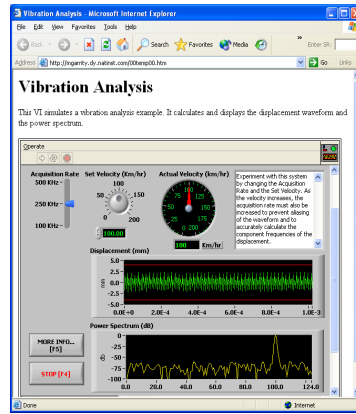
as TCP/IP, OPC, SQL database connectivity, and XML data formats.

Remote Panels

- Control NI LabVIEW VIs through a standard Web browser
- Easy setup—no programming required



LabVIEW Environment

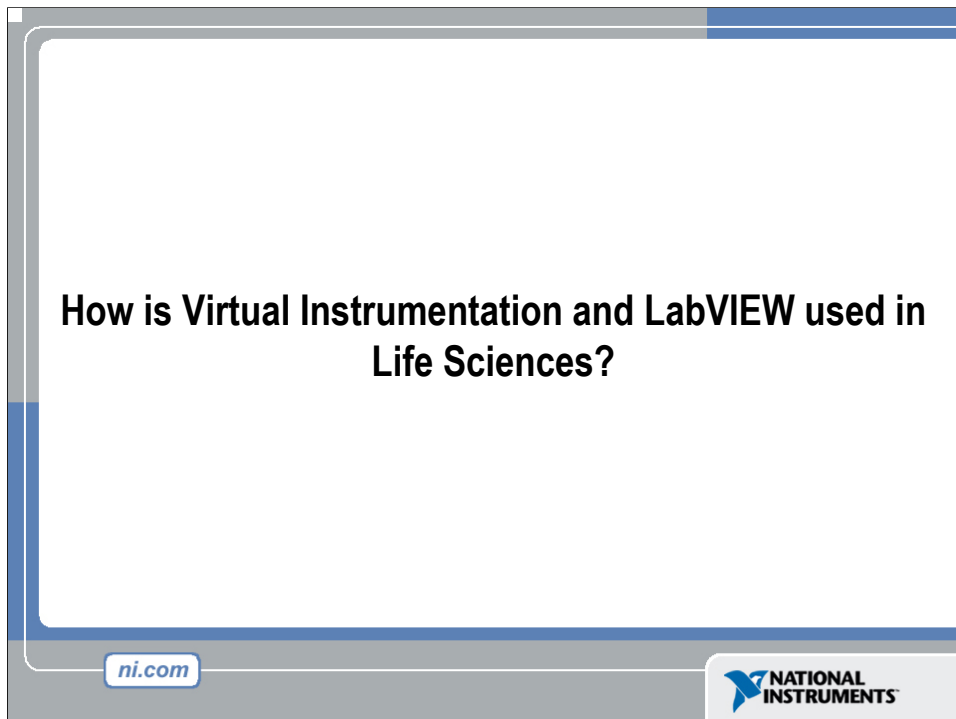


Web Browser

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One of the most exciting presentation and data-sharing tools included in the latest release of LabVIEW is called Remote Panels. This feature allows you to remotely control LabVIEW from any standard Web browser—anywhere in the world—without programming. You can remotely control an application situated in a hazardous environment or monitor and adjust your application while away from the office. Simply embed your VI Front Panel in a standard Web browser with one easy menu selection.



One misconception many in industry and academia have regarding LabVIEW is the range of applications where LabVIEW can be used. We've already discussed a wide range of applications where LabVIEW is used locally. Possible applications of LabVIEW are limited only by the creativity of the user.

National Instruments is constantly expanding possible uses for LabVIEW. Recently, National Instruments announced a partnership with Texas Instruments to incorporate DSP design with TI-Code Composer Studio into LabVIEW. LabVIEW also can incorporate Multisim (SPICE) designs for full circuit testing in the design process. LabVIEW also offers connectivity to Simulink models for improved simulation testing.

Test System to detect Heart Valve Sounds

LabVIEW and Data Acquisition

- Strain on the valve inlet strut
- Strain on the valve outlet strut
- Valve occluder position
- Pump piston position
- Left ventricular pressure (LVP)
- Ventricular acoustic signal



The electromechanical system formed by Structural Acoustics uses Windows-based LabVIEW and DAQ boards on a PC to perform an acoustic diagnostic procedure on prosthetic heart valves.

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The test system has several components: an artificial ventricle and circulatory flow loop; an analog servo-pump controller that accepts a necessary ventricular pressure. *The LabVIEW graphical programming language, which is highly efficient, becomes second nature very quickly.* DAQ boards.

Two 50-conductor ribbon cables connect the interface to the AT-MIO-16F boards. Using a single LabVIEW virtual instrument (VI), we can turn on the sensor interface, adjust the strain-gauge offsets, move the cutoff frequency of a programmable highpass filter, and adjust the ventricular volume so we can study the effects of heart size.

Satisfied with the adjustments, we measure six signals during a typical test:

- Strain on the valve inlet strut
- Strain on the valve outlet strut
- Valve occluder position
- Pump piston position
- Left ventricular pressure (LVP)
- Ventricular acoustic signal

at any point during the heartbeat. Usually, there is one trigger per heartbeat placed about 20 ms before the valve closes.

Microscope Control and Acquisition Systems

Study of 2 cells simultaneously with 2 different microscopes



- LabVIEW
- Motion card
- Data Acquisition



*The Confocal Microscope-
NMR Spectrometer
Hybrid Instrument*

*RasterScan configuration screen for a Pulsed Laser
Acquiring One Analog and One Digital Signal*



Testing of Hearing Aids



Knowles Electronics realized a 5 to 1 reduction in test time.

Using LabVIEW...

The original estimate for test time reduction was 50 percent. However, a typical receiver test showed a five to one reduction. The total test time went from 5.24 to 1.03 s.

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