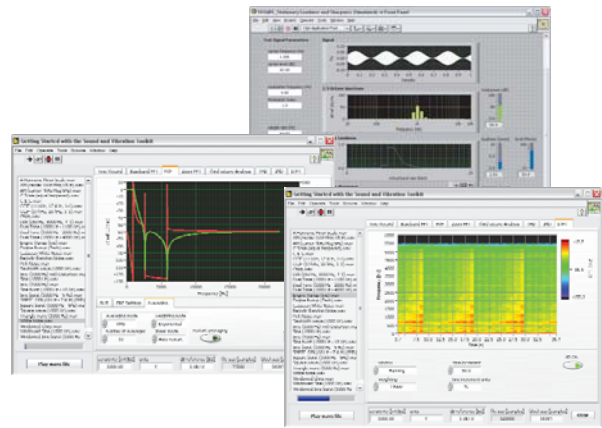# Sound and Vibration Analysis Software

NI Sound and Vibration Toolkit, NI Sound and Vibration Measurement Suite

Sound and Vibration Assistant

- Stand-alone interactive acquisition, analysis, and presentation environment
- Analysis for audio, noise and vibration, and machine condition monitoring applications
- Operator mode available for deploying Sound and Vibration Assistant applications
- Built-in data streaming and playback for postprocessing
- Extended functionality through NI LabVIEW
- New order analysis plots for displaying vibration sensor information

LabVIEW Analysis VIs

- Octave analysis
- Vibration and sound level
- Frequency analysis
- Filtering and weighting
- Audio measurements
- Tachometer processing
- Order tracking
- Swept sine
- Human vibration filters
- Torsional vibration
- Sound quality *NEW!*

Overview

National Instruments sound and vibration software provides a complete software solution for all audio, noise and vibration, and machine condition monitoring applications. Based on an open-analysis capability and a flexible measurement library, the NI Sound and Vibration Measurement Suite and NI Sound and Vibration Toolkit present a unique software-based measurement approach to creating customized applications. The sound and vibration software packages consist of two components:

- NI Sound and Vibration Assistant
- LabVIEW Analysis VIs

The Sound and Vibration Assistant is an interactive stand-alone software environment for quickly acquiring, analyzing, presenting, and logging acoustic and vibration measurements for all audio, noise and vibration, and machine condition monitoring applications. Rapid data acquisition hardware configuration and an interactive, drag-and-drop analysis library make it easy to quickly develop an application.

The LabVIEW Analysis VIs provide additional LabVIEW functions for power spectra, frequency response functions (FRFs), fractional-octave analysis, sound level measurements, order spectra, order maps, order extraction, sensor calibration, human vibration filters, and torsional vibration. The Sound and Vibration Measurement Suite also offers more than 50 ready-to-run examples to simplify the process of getting started with your sound and vibration applications.

Sound and Vibration Assistant

The Sound and Vibration Assistant is an interactive stand-alone software environment for quickly acquiring, analyzing, presenting, and logging acoustic and vibration measurements. It makes audio testing; noise, vibration, and harshness (NVH) testing; and machine condition monitoring simple by offering:

- A drag-and-drop interactive environment
- Rapid measurement configuration
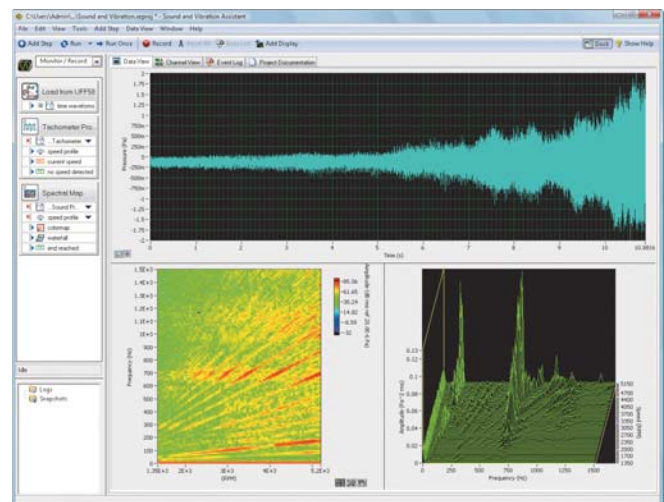- Extended functionality through LabVIEW

Figure 1. NI Sound and Vibration Assistant Performing Engine Run-Up Test

Sound and Vibration Analysis Software

Interactive Measurement Environment

The Sound and Vibration Assistant introduces an innovative approach to configuring your measurements using intuitive drag-and-drop steps. Combining the functionality of traditional noise and vibration analysis software with the flexibility to customize and automate projects, the Sound and Vibration Assistant helps you streamline your application.

Rapid Measurement Configuration

There are many built-in steps available for immediate use in the Sound and Vibration Assistant. You can instantly configure a measurement and analysis application with:

- Hardware I/O – generation and acquisition of signals from a variety of devices, including DAQ devices and modular instruments
- Signal processing – filtering, windowing, and averaging
- Time-domain analysis – sound and vibration level measurements
- ANSI and IEC fractional-octave analysis
- Frequency-domain analysis – power spectrum, frequency response, power-in-band, peak search, and distortion
- Order analysis – tachometer processing, order power spectrum, order tracking, and order extraction; Bode and polar, shaft centerline, and orbit and timebase plot steps now available
- Report generation – drag and drop measurement results to Microsoft Excel or export data to Microsoft Word or UFF58 files
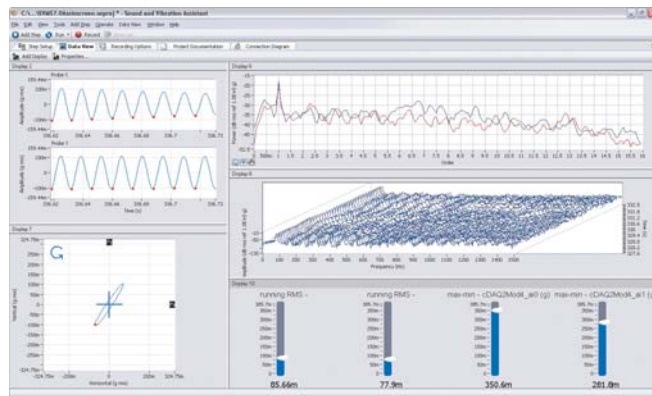

Figure 2. Characterize vibration order with drag-and-drop data analysis of vibration sensors data.

Extended Functionality through LabVIEW

Reuse your measurement applications developed with the Sound and Vibration Assistant in LabVIEW by converting projects into LabVIEW block diagrams. Use LabVIEW, a full-featured graphical programming environment, to further automate your application or customize your analysis.
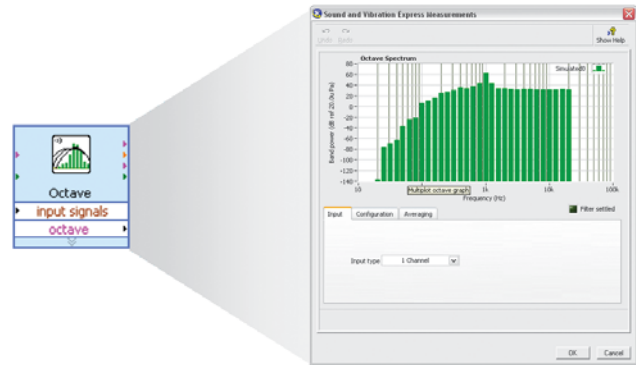

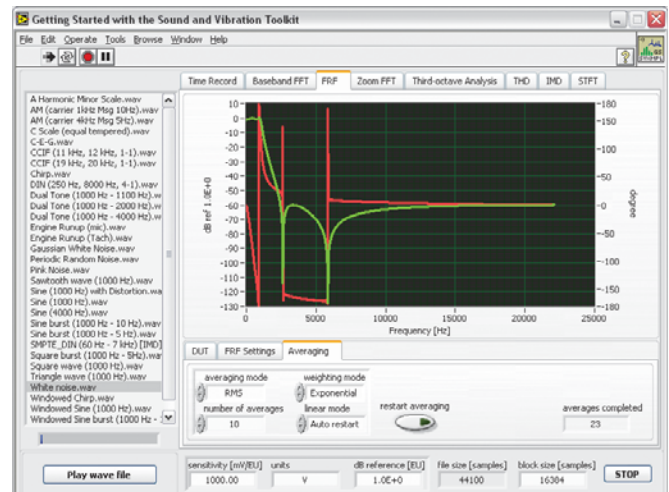Figure 3. Octave Analysis Express VI for LabVIEW

Figure 4. Frequency Response Analysis for LabVIEW

LabVIEW Analysis VI Capabilities

Sound and vibration analysis often begins with signal acquisition from microphones, accelerometers, displacement probes, or tachometers. Following acquisition, you can associate the acquired signal with characteristics such as sensor sensitivity, an engineering unit, and a decibel (dB) reference. All routines track these parameters to perform single or multichannel measurements and produce properly labeled, scaled, and calibrated results. Sound and vibration analysis includes order-based analysis such as order tracking, order extraction, and tachometer signal processing. Order analysis is a tool for examining dynamic signals generated by mechanical systems that include rotating or reciprocating components. Complementing the power spectrum and other frequency-domain analysis standards, order analysis works even when the signal source undergoes rotational speed variations. In addition, the sound and vibration analysis includes human vibration filters as well as torsional vibration. Human vibration refers to the effects of mechanical vibration on the human body. Measuring and analyzing human vibration signals can help control the negative effects of mechanical vibration on the human body. Torsional vibration is a common phenomenon for rotating machinery such as engines, compressors, and turbines. Rotating components, such as shafts and couplings, rotate when torque is applied. Monitoring these torsional vibrations in a rotating system helps to ensure that the system operates properly. Refer to page 4 for a detailed list of the LabVIEW analysis functions.

In addition, the Sound and Vibration Measurement Suite now supports full-featured sound quality analysis. Sound quality engineering is the study of the subjective human perception of sounds. It uses various algorithms such as stationary and time-varying loudness, sharpness, roughness, fluctuation strength, and tonality to quantify the quality of a sound. This helps you quickly set up tests to quantify concepts such as noise or harshness.

Real-World Applications

The Sound and Vibration Measurement Suite contains features for audio, acoustics, and vibration applications, such as zoom fast Fourier transform (FFT), octave analysis, short-time Fourier transform, order analysis, and many more time and frequency analysis tools. Significantly improve your productivity with examples based on real-world measurements such as engine run-up, frequency response, and octave analysis. Use order analysis for mechanical systems that include rotating or reciprocating components, such as turbines, compressors, pumps, and engines, in applications such as machine condition monitoring or NVH testing.

Audio Measurements and Swept-Sine Analysis

The Sound and Vibration Measurement Suite includes numerous functions for audio measurements such as gain, phase, THD, IMD, dynamic range, phase linearity, and swept-sine analysis. Also included are simple modular examples of all of these measurements, so you can quickly combine analog output, analog input, and data analysis to build a customized application. Swept sine is a powerful analysis technique to measure frequency response. With this analysis function, you can easily generate a frequency-swept stimulus signal and measure the output of the device under test (DUT). Unlike conventional broadband frequency response measurements, swept-sine analysis adds the capability to measure frequency-dependent distortion and to account for device-specific settling requirements. In addition to audio test, swept-sine analysis is an excellent tool for many mechanical vibration testing applications.

Noise, Psychoacoustics, and Vibration

Using the Sound and Vibration Measurement Suite, you can readily handle many common noise and vibration applications. For example, with zoom FFT analysis, it is possible to look with improved resolution in the frequency range of interest. The Sound and Vibration Measurement Suite offers time- and frequency-domain integration, so you can easily convert the signals acquired from accelerometers to velocity and/or displacement for additional analysis. Also, sound and vibration level functions feature linear averaging, exponential averaging, and peak hold. With the built-in fractional-octave analysis, you can perform measurements with any number of bands at any sampling frequency. With sound quality algorithms, you can characterize sounds from the perspective of human hearing. Using these tools, you can quickly analyze harshness, sharpness, and other qualitative psychoacoustic concepts, which are necessary to ensure good acoustics for your designs. The acoustical and vibration analysis tools provided help you quickly verify your product for the following standards.

- IEC 61260: 1995, Class 1
- IEC 61672: 2002, Class 1
- JIS C 1509-1: 2005
- JIS C 1514: 2002
- ANSI S1: 11 - 2004, Class 1
- ANSI S1.4: 1983
- ANSI S1.42: 1986
- ISO 8041: 2005(E)
- ISO 532: 1975 *NEW!*
- DIN 45631: 1991 *NEW!*
- DIN 45631/A: 2008 *NEW!*

Machine Condition Monitoring (MCM) and Machine Health

The Sound and Vibration Measurement Suite is ideal for machine monitoring, machine health, and machine efficiency applications with order tracking and slow-roll compensation built in. You can develop your application faster by using examples for tachometer processing, order spectra, and waterfall plots. If you are performing measurements in a production test environment, you can easily apply limit testing on any measurement result from this suite, such as time-domain data, order spectra, scalar measurements, and many more. In addition, the Sound and Vibration Measurement Suite now includes torsional vibration analysis functions. Torsional vibration is a common phenomenon for rotating machinery such as engines, compressors, and turbines. Rotating components, such as shafts and couplings, rotate when torque is applied. Monitoring these torsional vibrations in a rotating system helps to ensure that the system operates properly.

Ordering Information

NI Sound and Vibration Measurement Suite,
  Includes 1 Year Standard Service 779696-09
NI Sound and Vibration Toolkit,
  Includes 1 Year Standard Service 777970-09

BUY NOW!

For complete product specifications, pricing, and accessory information, call 800 813 3693 (U.S.) or go to **ni.com/soundandvibration**.

Sound and Vibration Analysis Software

Function List and Description

Measurements	Features	Description
Calibration	End-to-end calibration – microphones, accelerometers, propagation delay	Use the Calibration VIs to perform an end-to-end calibration of microphones, accelerometers, and other dynamic sensors. With the Calibration VIs, you can perform an end-to-end calibration on a selected channel and measure the propagation delay of the measurement device.
Display	Waterfall display, colormap display, octave graph, magnitude/phase display, cascade plot,[1] Bode plot, polar plot,[1] orbit plot,[1] timebase plot,[1] shaft centerline plot[1]	Use the Display VIs and indicators to configure the graphs and plots included to show various measurement results.
Distortion Measurements	THD, THD+N, SINAD, IMD, SNR	Use the Distortion VIs to perform distortion analyses on time-domain data. The SNR, SINAD, THD+N, and THD VIs return the complex spectrum and the measurement results. You can use these VIs sequentially to improve performance. With the Distortion VIs, you can measure harmonic distortion, intermodulation distortion, and phase nonlinearity in the DUT.
Envelope Analysis[1]	Envelope detection[1]	Use envelope detection analysis to identify mechanical faults that have an amplitude-modulating effect on the vibration signal of a machine.
Frequency Analysis	Power spectrum, FFT, zoom FFT, power spectral density, frequency response, coherence, cross spectrum, peak search, power in band	Use the Frequency Analysis VIs to perform baseband and zoom frequency analyses. Single-channel measurements include power spectrum, power spectral density, magnitude and phase spectra, and real and imaginary spectra. Apply these measurements on a single channel or multiple channels at the same time, using the same polymorphic VIs. Dual-channel measurements include cross spectrum, frequency response, and coherent output power. Compute frequency response measurements between a single stimulus and a single response, or multiple stimuli and multiple responses (MIMO). With extended measurement capabilities, you can perform additional measurements such as peak detection, power in band, unit conversions, and limit testing.
Generation	Continuous tone, continuous dual tone, multitone, frequency flat chirp, white noise, pink noise, swept sine with custom amplitude	Use the Generation VIs to generate test signals for sound and vibration measurements. The Pink Noise Waveform VI generates a continuous pink noise waveform.
Human Vibration[1]	Human vibration weighting filters: hand-arm vibration signal, whole-body vibration signal, and low-frequency whole-body vibration signal	Use the human vibration weighting filters to monitor human vibration signals and help control the negative effects of mechanical vibration on the human body. Human vibration weighting filters include three types of human vibration signals: hand-arm vibration signal, whole-body vibration signal, and low-frequency whole-body vibration signal.
Integration	Convert acceleration to velocity, convert acceleration to displacement	Use the Integration VI to perform time-domain integration to convert acceleration to velocity (single integration), acceleration to displacement (double integration), and velocity to displacement.
Limit Testing	Mask testing; high (max), low (min); both high/low limits	Use the Limit Testing VI to perform range detection and mask testing on time-domain data, frequency spectra, octave spectra, order spectra, peaks, and scalar measurement results.
Octave Analysis	IEC full, 1/3, 1/6, 1/12, 1/24 octave ANSI full, 1/3, 1/6, 1/12, 1/24 octave	Use the Octave Analysis VIs to perform octave, 1/3 octave, and 1/n octave measurements. You can also perform extended measurements such as weighting and limit testing. The Octave Analysis VIs offer a complete set of tools to perform fractional-octave analysis, including full, 1/3, 1/6, 1/12, and 1/24 octave-band analysis. The Octave Analysis VIs accommodate any sampling frequency and any number of fractional-octave bands.
Order Analysis[1]	Gabor transform (offline);[1] resampling (online);[1] order power spectrum;[1] order waveform, magnitude, and phase[1]	Use the Order Analysis VIs to calculate order-related results such as order map, order magnitude and phase, order spectrum, and order waveform.
Single-Tone Measurements	Phase mismatch, phase linearity, group delay, gain, dynamic range, spurious-free dynamic range, idle channel noise, crosstalk/separation	The Single-Tone VIs perform single-tone measurements, defined as a group of measurements where the excitation is a single tone. You can measure gain and phase, crosstalk, dynamic range, idle channel noise, and spurious-free dynamic range. Each VI returns the complex spectrum and the measurement results. You can use these VIs sequentially to improve performance.
Scaling	Voltage to engineering units with decibel reference	Use the Scaling VI to scale time-domain signals to engineering units. The Scaling VI operates on voltage channels not previously scaled in Measurement & Automation Explorer (MAX).
Slow-Roll Compensation[1]	Slow-roll compensation[1]	Use the Get Vector Reference VI to extract the vector reference signal. Use the Get Even Angle Reference VI to extract the even-angle reference signal from the slow-roll vibration and tachometer signal. Use the Compensate Vector Signal VI to remove the slow-roll errors in the vector signal. Use the Compensate Even Angle Signal VI to remove the slow-roll errors from the even-angle signal.
Sound Level	L_{eq}, exponential, peak sound level	Use the Sound Level VIs to perform sound level measurements and return level results in decibels (dB). The Sound Level VIs offer typical sound level measurements, including equivalent continuous averaging (L_{eq}), exponential averaging, and peak hold.
Sound Quality	Stationary and time-varying loudness, sharpness, roughness, fluctuation strength, and tonality	Use the Sound Quality VIs to determine the quality of sound as perceived by the human ear. This type of analysis is commonly used in the psychoacoustics realm to better understand the components of a sound wave and the effects these traits can have.
Swept-Sine Analysis	Frequency response – gain and phase, rms levels, THD, Nyquist and Bode plot, individual harmonics	Use the Swept Sine VIs to perform swept-sine measurements. Configure the acquisition hardware and perform measurements such as stimulus rms level, response rms level, magnitude and phase response, total harmonic distortion, and individual harmonic distortion. Swept-sine analysis is typically used to characterize the frequency response of a DUT.
Tachometer Signal Processing[1]	Analog and digital tachometer signal processing[1]	Use the Tachometer Signal Processing VIs to process analog and digital tachometer signals.
Torsional Vibration[1]	Torsional vibration	Use the Torsional Vibration Measurement VIs to measure torsional vibration in a rotating system.
Transient Analysis	Short-time Fourier transform, shock response spectrum	The Transient Analysis VIs offer two techniques for obtaining information about transient signals. Use the short-time Fourier transform (STFT) to extract frequency information as a function of time. Use the shock response spectrum (SRS) to evaluate the severity of a shock signal.
Vibration Level	rms, exponential, peak, crest factor, max-min	Use the Vibration Level VIs to perform vibration level measurements and return level results with a linear scale. The Vibration Level VIs offer level measurements typically used for vibration measurements. Averaging modes include rms averaging, exponential averaging, max-min, and peak hold.
Weighting Filters	A, B, C weighting; ITU-R 468-4; Dolby CCITT, C-Message	Use the Weighting VIs to perform frequency weighting on time-domain data. With the Weighting VIs, you can apply A, B, or C weighting filters on the time-domain signal. Additionally, ITU-R 468-4 and Dolby filters are available for radio-communications applications, and C-message and CCITT filters are available for telecommunications applications.

[1]Note: These functions are included only with the Sound and Vibration Measurement Suite.

Sound and Vibration Analysis Software

	NI Sound and Vibration Toolkit		NI Sound and Vibration Measurement Suite	
	NI Sound and Vibration Assistant	LabVIEW Analysis VIs	NI Sound and Vibration Assistant	LabVIEW Analysis VIs
Interactive analysis	✓	–	✓	–
Code generation	✓	–	✓	–
UFF58 file I/O	✓	✓	✓	✓
FFT analysis	✓	✓	✓	✓
Zoom FFT	✓	✓	✓	✓
Subset FFT	–	✓	–	✓
Frequency response function (FRF)	✓	✓	✓	✓
Peak search	✓	✓	✓	✓
Sound level	✓	✓	✓	✓
Vibration level	✓	✓	✓	✓
1/n octave	✓	✓	✓	✓
Weighting filters	✓	✓	✓	✓
Integration	✓	✓	✓	✓
Harmonics	✓	✓	✓	✓
Distortion (THD, THD+N, SINAD)	✓	✓	✓	✓
Intermodulation distortion (IMD)	✓	✓	✓	✓
Tone detection	✓	✓	✓	✓
Spurious-free dynamic range (SFDR)	✓	✓	✓	✓
Crosstalk	✓	✓	✓	✓
SNR	✓	✓	✓	✓
Swept sine	–	✓	–	✓
Limit testing	✓	✓	✓	✓
Pink noise	–	✓	–	✓
Shock response spectrum (SRS)	–	✓	–	✓
Short-time Fourier transform (STFT)	–	✓	–	✓
Human vibration filters	–	–	–	✓
Torsional vibration	–	–	–	✓
Tachometer processing	–	–	✓	✓
Order power spectrum	–	–	✓	✓
Order tracking	–	–	✓	✓
Order extraction	–	–	✓	✓
Angular resampling	–	–	–	✓
Envelope detection	–	–	–	✓
Waterfall plot	✓	✓	✓	✓
Spectral map	–	–	✓	✓
Bode plots	✓	✓	✓	✓
Orbit and shaft centerline plot	–	–	✓	✓

Table 1. Sound and Vibration Analysis Software Selection Guide

Recommended Hardware

The Sound and Vibration Measurement Suite includes more than 50 examples that work with both dynamic signal acquisition and multifunction data acquisition devices. For sound and vibration data acquisition, National Instruments recommends DSA devices. With 24-bit ADCs and DACs and integrated antialiasing filters, DSA devices are ideal for acoustic, noise, and vibration measurements.

There are numerous system requirements to consider when selecting data acquisition hardware for measuring or generating sound and vibration signals. From IEPE signal conditioning for accelerometers and microphones to high dynamic range (up to 118 dB) and multichannel synchronization (up to 13,000 channels), National Instruments offers a wide range of hardware products for your applications.

Product	Bus	Input Resolution (bits)	Dynamic Range (dB)	Sampling Rate per Channel	Analog Inputs	Input Range	Gain Settings	Coupling	TEDS[1] Support	Analog Outputs
High-Performance										
NI 4461	PXI, PCI	24	118	204.8 kS/s	2	±42 V to 316 mV	-20 to 30 dB in 10 dB increments	AC/DC	✓	2
NI 4462	PXI, PCI	24	118	204.8 kS/s	4	±42 V to 316 mV	-20 to 30 dB in 10 dB increments	AC/DC	✓	0
High-Density										
NI 4495	PXI	24	114	204.8 kS/s	16	±10 to 1 V	0 and 20 dB	DC	✓	0
NI 4496	PXI, PXI Express	24	114	204.8 kS/s	16	±10 to 1 V	0 and 20 dB	AC	✓	0
NI 4498	PXI, PXI Express	24	114	204.8 kS/s	16	±10 V to 316 mV	0 and 30 dB in 10 dB increments	AC	✓	0
Low-Cost										
NI 4472	PXI, PCI	24	110	102.4 kS/s	8	±10 V	N/A	AC/DC	–	0
NI 4474	PCI	24	110	102.4 kS/s	4	±10 V	N/A	AC/DC	–	0
Portable/Compact										
NI USB-9233	USB	24	102	50 kS/s	4	±5 V	N/A	AC	–	0
NI USB-9234	USB	24	102	51.2 kS/s	4	±5 V	N/A	AC/DC	–	0

[1]TEDS = transducer electronic data sheet

Table 2. NI Dynamic Signal Acquisition Hardware

NI Services and Support

NI has the services and support to meet your needs around the globe and through the application life cycle – from planning and development through deployment and ongoing maintenance. We offer services and service levels to meet customer requirements in research, design, validation, and manufacturing. Visit **ni.com/services**.

Local Sales and Technical Support

In offices worldwide, our staff is local to the country, giving you access to engineers who speak your language. NI delivers industry-leading technical support through online knowledge bases, our applications engineers, and access to 14,000 measurement and automation professionals within NI Developer Exchange forums. Find immediate answers to your questions at **ni.com/support**.

Training and Certification

NI training is the fastest, most certain route to productivity with our tools. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. We schedule instructor-led courses in cities worldwide, or we can hold a course at your facility. We also offer a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit **ni.com/training**.

NATIONAL INSTRUMENTS™
Certified Alliance Partner

Professional Services

Our NI Professional Services Team is composed of NI applications and systems engineers and the worldwide National Instruments Alliance Partner program of more than 600 independent consultants and integrators. Services range from startup assistance to turnkey system integration. Visit **ni.com/alliance**.

Software Maintenance and Support Programs

NI offers service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Membership in our service programs ensures that you always have the latest advances in productivity and receive live, on-demand access to NI applications engineers through phone and e-mail to assist in developing your solutions. Service programs are cost-effective and simplify software purchasing as an annual, fixed cost, making it easier to plan and budget than intermittent individual upgrades. For details, visit **ni.com/ssp**.

No Service Membership
- Upgrades purchased separately
- Online support only through KnowledgeBase, Discussion Forums, and Developer Zone
- Access to KnowledgeBase, example code, troubleshooting wizards, solutions, and white papers

Standard Service and Support Membership
- Automatic upgrades included
- Access to all online support including KnowledgeBase, Discussion Forums, Developer Zone, example code, troubleshooting wizards, solutions, and white papers
- Support by NI applications engineers through direct phone or e-mail access
- Exclusive access to on-demand training modules through the Services Resource Center

Premier Service and Support Membership
- All the benefits of Standard Service
- Support by NI senior applications engineers through direct phone or e-mail access with extended hours of operation

NATIONAL INSTRUMENTS™

ni.com • 800 813 3693

National Instruments • info@ni.com