Noise Mapping Reference Architecture

Overview

Numerous applications cannot sustain a sufficient sampling rate for lengthy acquisitions or generations. In these situations, you must compromise by using a slow enough sampling rate to transfer data over the bus or by sampling at the necessary high speeds for the short periods of time that onboard instrument memory can accommodate. Neither sacrifice is desirable. You can address this need through high-speed streaming, which transfers data to or from an instrument at a rate high enough to sustain continuous acquisition or generation. This is accomplished by having a bus with sufficient bandwidth for overall data throughput and a system that stores the entire acquisition or generation waveform. High-speed data streaming of noise mapping signals is a common application because data collection is often desired at high rates for an extended period of time.

Application

Introduction to Noise Mapping

This concept of noise mapping refers to either a 1D or 2D array of microphones used to map the locations of noise in some environment. This theory is shown in Figure 1.

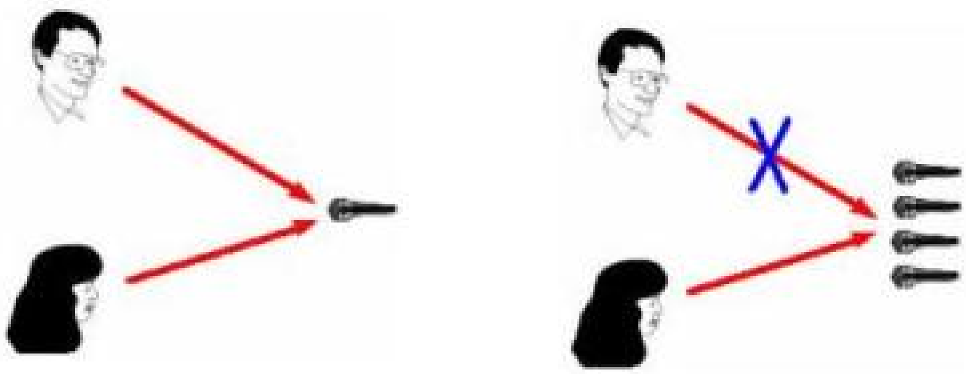

Figure 1. When using multiple microphones in a 1D array, you are able to determine the location of the noise.

Using one microphone acquires noise from multiple sources, but it does not provide any information as to the location of the noise. When using multiple microphones in a 1D array as shown in Figure 1, you are able to determine the location of the noise. This is because of the phase delay in the signal acquired by the four microphones. This concept is better explained in Figure 2.

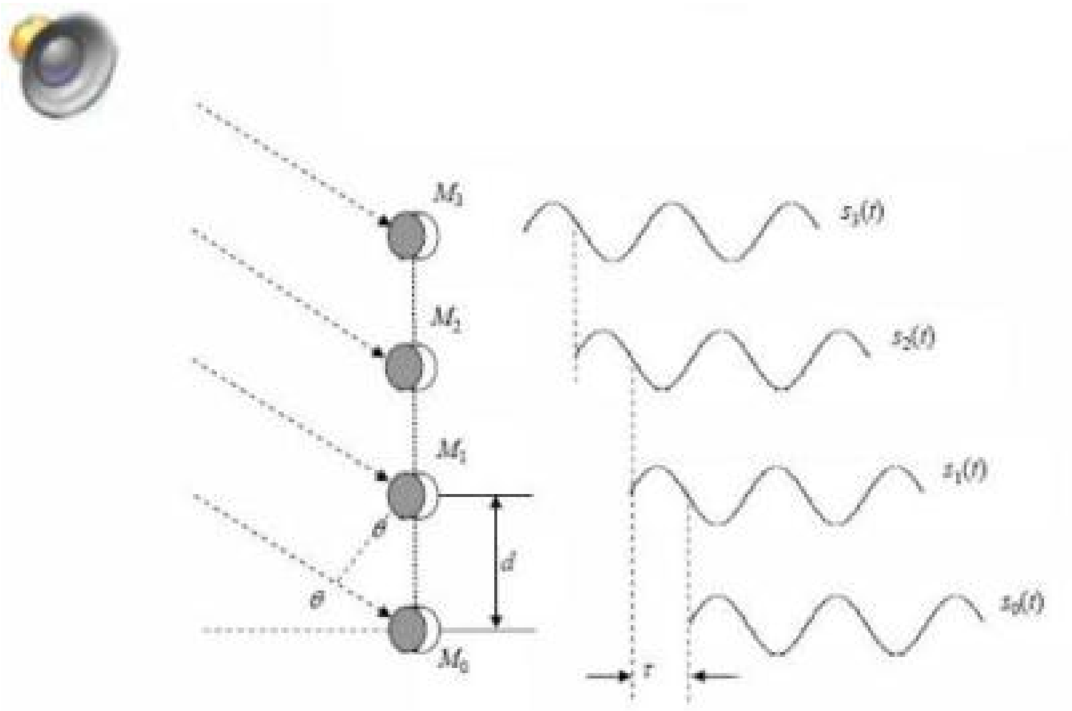

Figure 2. Phase Delay in the Signal Acquired by Four Microphones

A single source is generating noise similar to the person above speaking into the microphones. Because the distance between the person and each microphone is not the same, there is a delay in the signal acquired. You can measure this phase delay by simultaneously acquiring noise from the four microphones and then comparing the data. Then you can extrapolate the location of the noise.

The 1D array of microphones is great for determining the position of noise along a single axis. However, with a 2D array of microphones, you can determine the position of noise along two axes. For example, Boeing used a 2D array of microphones to map the noise coming from its aircraft as they landed. Through this, Boeing could determine which parts of the aircraft create the most disturbances. Figure 3 shows the Boeing 2D array of microphones placed on a runway.

Figure 3. Boeing 2D Array of Microphones Placed on a Runway

In this example, Boeing strategically placed more than 600 microphones on the runway and acquired data from each microphone simultaneously as planes landed. Boeing streamed the data to disk at high rates for future analysis to determine the location of the noise mapped to the image of the plane (see Figure 4).

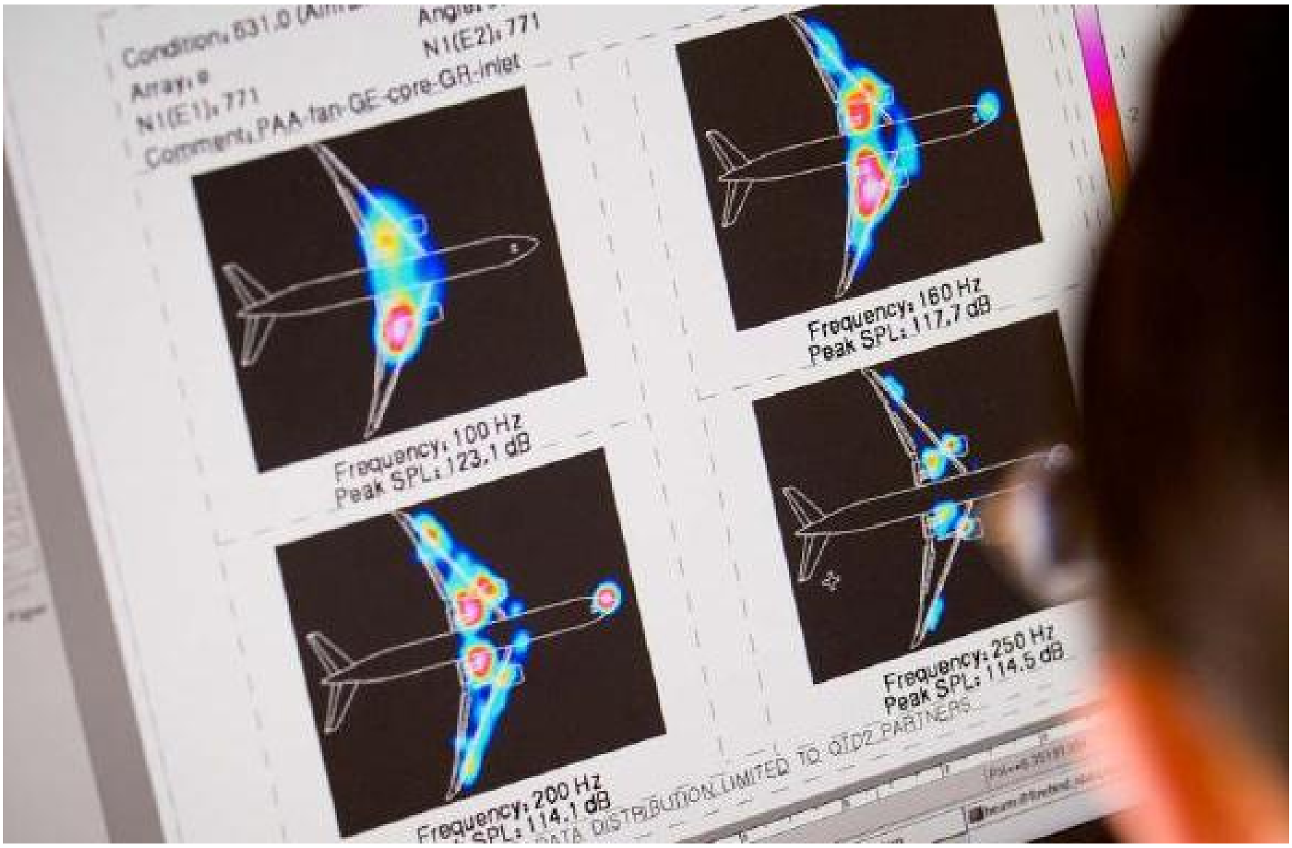

Figure 4. Boeing streamed the data acquired from the microphones to disk at high rates for future analysis to determine the location of the noise mapped to the image of the plane.

To learn more about the Boeing application, read Boeing Measures Reduced Aircraft Noise Emissions with NI PXI and LabVIEW.

Higher Channel Count Increases Spatial Resolution

With the decrease in sensor cost and increase in spatial resolution demand, there has been a significant increase in the channel count for these 1D or 2D systems. In the Boeing application referenced above, more than 600 microphones acquired data at high rates and the data was streamed to disk. For its next project, Boeing foresees using more than 1,000 microphones to get even more spatial resolution. Figure 5 provides a better understanding of the impact of microphone count on spatial resolution.

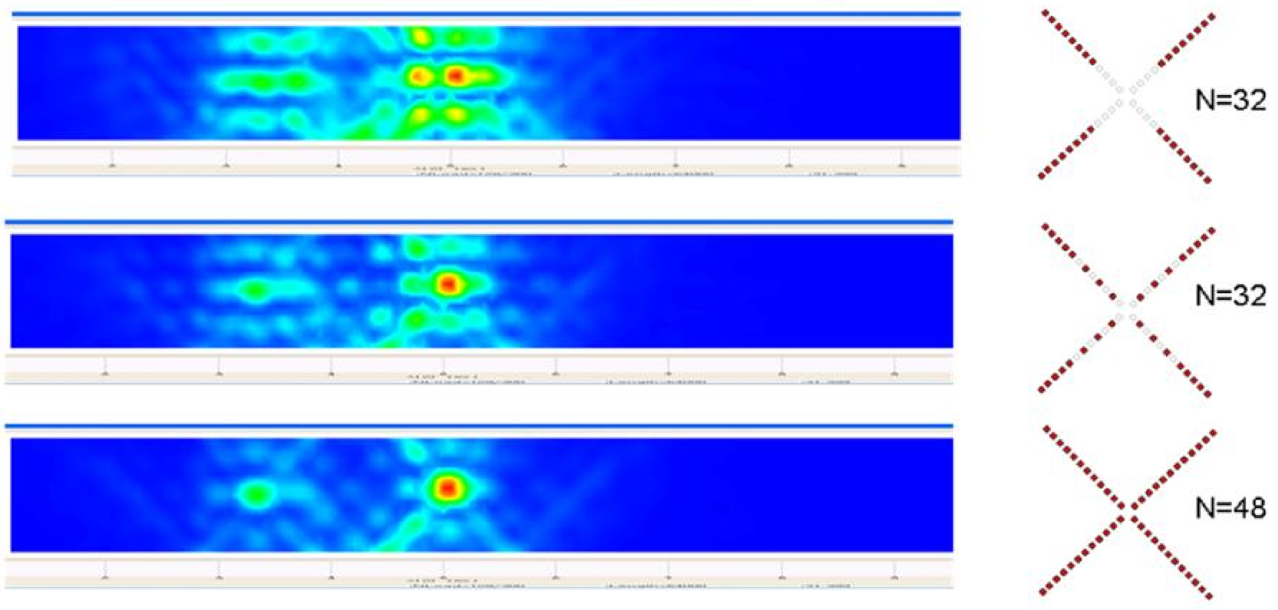

Figure 5. Location and number of sensors make a big difference in the spatial resolution.

Figure 5 shows the same acquisition performed with three different sensor layouts. This diagram highlights an important point: location and number of sensors make a big difference in the spatial resolution. More sensors, when placed properly, help more accurately determine the location of noise.

As sensor count increases, so does the number of data acquisition channels you need. This also leads to an increase in the amount of data acquired per second. Because of this increase, your data transfer bus needs to be large enough to sustain acquisition and your hard drive(s) needs to be large enough to receive and record all of the data for as long as the acquisition is necessary.

Hardware

Sound and Vibration Hardware

With National Instruments sound and vibration measurement hardware, you have the flexibility to create a wide variety of custom automated measurement systems on industry-standard computer platforms. Systems can combine data acquisition, modular instrumentation, signal conditioning, vision, motion, and more. NI dynamic signal acquisition (DSA) devices are designed specifically for applications requiring audio, noise, and vibration measurements. They can acquire signals at sampling rates up to 204.8 kS/s with 24-bit resolution and can be used in PXI, PCI, and USB platforms for flexible, accurate measurements.

Options are available to build systems that synchronize acquisition on up to 5,000 channels of signals, such as accelerometers and microphones. You can synchronize NI DSA devices with less than 0.1 deg phase mismatch between channels.

To learn more, please visit Sound and Vibration Measurement Hardware.

Software

NI LabVIEW Software

National Instruments LabVIEW is an ideal programming language for streaming applications because of its intuitive support of file I/O and efficient design patterns, as well as its inherent parallelism. Because of the time-critical nature of communicating with instruments and reading from or writing this data to disk at high rates, it is not possible to use a traditional single-loop design pattern. The limitation of this type of architecture is that instrument and disk access must occur in lockstep. If either experiences any type of communication delay, it negatively impacts the performance of the other. By using a producer/consumer design pattern and eliminating the sequential, alternating access of instrument and disk, each can operate at its own rate, with LabVIEW providing buffer overflow or underflow protection through the use of additional buffering in host PC memory. LabVIEW makes this process incredibly easy through its native support of queue operations. Additionally, with its default ability to create multiple threads, LabVIEW can independently execute producer and consumer loops. With multiprocessor computers and multicore processors, streaming experiences a significant performance advantage when using this type of program architecture.

To learn more, please visit ni.com/labview.

Sound and Vibration Software Add-Ons for LabVIEW

National Instruments sound and vibration analysis software, including the NI Sound and Vibration Measurement Suite and the NI Sound and Vibration Toolkit, provides signal processing functionality for performing audio measurements, fractional-octave analysis, frequency analysis, transient analysis, and order tracking. NI sound and vibration analysis software features NI Sound and Vibration Assistant, an interactive software for quickly acquiring, analyzing, and logging acoustic, noise, and vibration data. With a configuration-based, flexible measurement library and open-analysis capability, Sound and Vibration Assistant is designed for quick data capture through a unique software-based measurement approach to create customized applications.

Sound and Vibration Assistant offers the ability to continually interact with live data to modify analysis settings dynamically while logging data to disk for more analysis later. For example, you can vary the weighting and bandwidth of an octave spectrum while recording sound level data or adjust the window applied to a power spectrum while trending overall vibration readings. With Universal File Format (UFF58) file I/O support, you can acquire data from NI 24-bit DSA devices, including low-cost, USB DSA devices, and share the data easily between other commonly used sound and vibration analysis applications including modal analysis software.

The Sound and Vibration Measurement Suite contains the most comprehensive collection of LabVIEW analysis VIs for noise, vibration, and harshness; machine condition monitoring; and audio test applications. Express VIs for power spectra, frequency response, ANSI and IEC fractional octave analysis, distortion measurement, order spectra, and colormap processing are included to shorten time to first measurement in LabVIEW. You can quickly and efficiently begin applications with more than 50 ready-to-run LabVIEW example code bases provided in the Sound and Vibration Measurement Suite.

To learn more, please visit Sound and Vibration Measurement Software.

Drivers and Considerations

NI-DAQmx driver software goes far beyond a basic data acquisition driver to deliver increased productivity and performance in data acquisition and control application development. NI-DAQmx controls every aspect of your DAQ system (including NI signal conditioning devices), from configuration, to programming in LabVIEW, to low-level operating system and device control. Quickly gather real-world data with measurement-ready virtual channels and DAQ Assistant. Build your applications with measurement-specific VIs, functions, data types, and analysis integrations. Reliably get your measurements faster with optimized DMA data transfer and single-point I/O. NI-DAQmx works with NI LabVIEW, LabVIEW SignalExpress, and LabWindows™/CVI as well as C/C++, Visual Basic, Visual Basic .NET, and C#. Along with LabVIEW, NI-DAQmx is one of the principal reasons National Instruments is a leader in virtual instrumentation and PC-based data acquisition.

To learn more, please visit NI-DAQmx Software.

Solutions

For high-channel-count DSA, you can choose from a variety of system architectures depending on the amount of channels and sampling rates you need. In the following section, explore four system architectures you can use as solutions for these high-channel-count, high-sampling-rate systems.

High-Channel-Count Noise Mapping System (up to 272 channels)

This architecture provides a tightly synchronized, single-chassis streaming solution scalable up to 272 channels.

For more information, please visit the Noise Mapping System Bundle**.**

Multichassis Synchronization (up to 5000 channels)

High-Channel, High-Performance Multichassis System (up to 13000 channels))

High-Channel, Medium-Performance Multichassis System (up to 3300 channels)

Medium-Channel, Low-Cost Multichassis System (up to 570 channels)

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