Need an Instrument that does not exist? Just Build It!

Authors

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NI Product(s) Used

LabVIEW
Sound and Vibration toolkit
TestStand
PXIe-4145 Source Measure Unit
PXI-2567 Relay Module
PXI-5412 Arbitrary Waveform Generator
PXI-5152 Scope
PXIe-6363 Multifunction DAQ
PXIe-6556 High-Speed Digital Input Output
PXIe-4464 DSA Analog Input
PXIe-4610 Power Amplifier
PXIe-4463 DSA Analog Output

Category

Electronics and Semiconductor

Application Area

Semiconductor Characterization and Validation.

The Challenge

Characterizing modern microphones requires many special tests where NI hardware meets the physical requirements, once configured in LabVIEW.

The Solution

Merging the wide array of NI hardware, using the PXI chassis framework allowed all measurements to be taken from one instrument rack, even in complicated timing interactions.

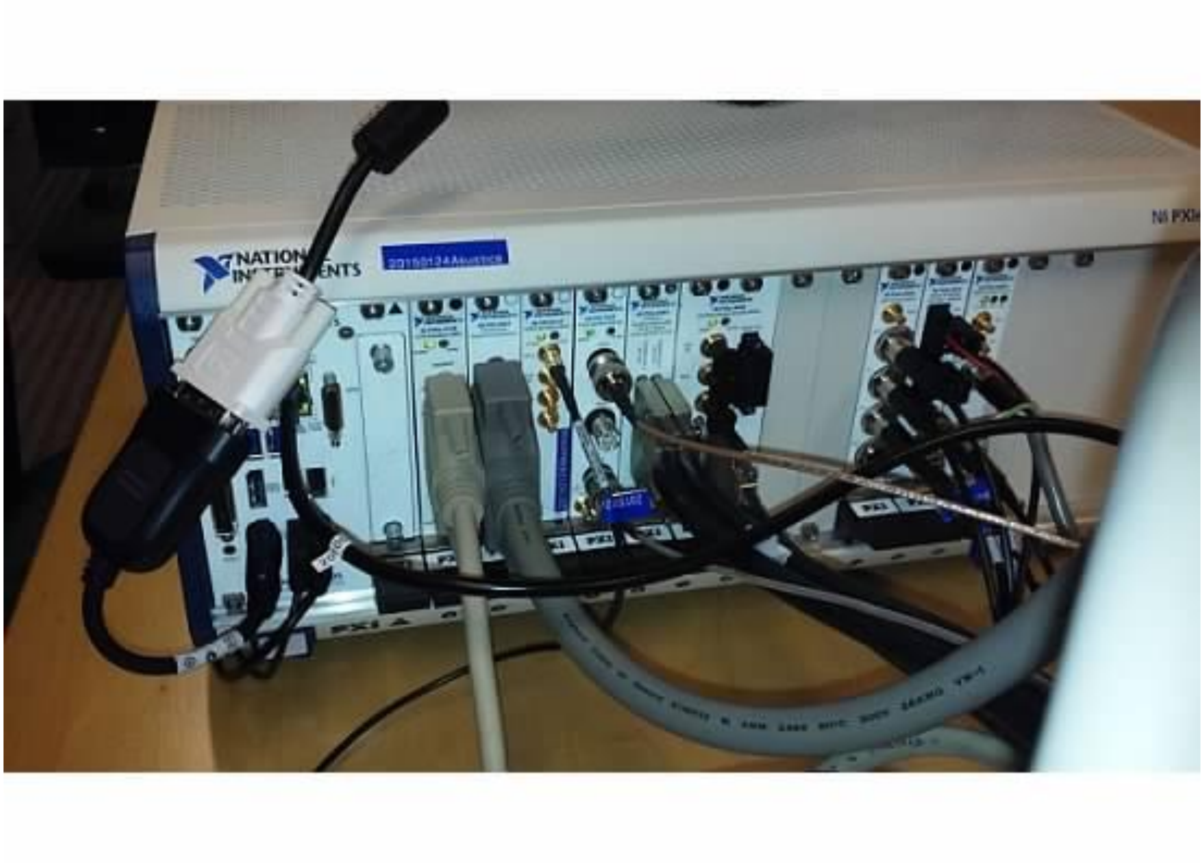

Figure 1 A variety of modular instruments were used to charaterize analog and digital microphones.

Introduction

For 25 years, Data Science Automation® (DSA) has been a premier automation systems integrator, leveraging commercial off-the-shelf tools in the design and implementation of custom-engineered, complete, and highly-adaptive solutions in laboratory automation, embedded/new product development, manufacturing and test automation. The company provides an extensive array of automation engineering, programming, consulting & training services to dramatically improve research, manufacturing, government & business operations. DSA is fast and methodical, staffed with exceptional, multi-disciplinary, NI Certified professionals that consistently apply CSIA-certified best practices to deliver the lowest total cost of ownership.

Characterizing modern microphones has changed significantly from merely measuring sensitivity, Signal to Noise Ratio (SNR), and bandwidth. Modern microphones, such as in cell phones, come in both analog and digital forms. Testing now includes the classic checks but also power consumption, power supply noise rejection, speed of transition from power standby state to operation, as well as many other test types. Instruments exist that are ready made for analog microphones, but adapting them for use with digital microphones requires special hardware. To support simultaneous testing of digital microphones that share a common data line requires even more specialized hardware.

Rather than creating a monolithic custom instrument, we leveraged the flexibility of the PXI platform to continuously create the instruments needed for each test. To this end, a test station was assembled using NI modular instruments to be able to perform all of the required measurements. This paper will discuss how the National Instrument Modular Instruments, LabVIEW, and other products were used to help us “do more, innovate faster and easily integrate new technologies” (see Figure 1) in our quest to completely characterize modern microphones.

National Instruments produces a wide variety of modular instruments that will replace traditional desk-top equipment and integrated cleanly into a LabVIEW/TestStand application. Packaging the various instruments into a set of small LabVIEW VIs allows a test suite to be developed and utilized in TestStand. Some of the test steps and their associated libraries are shown in figure 2.

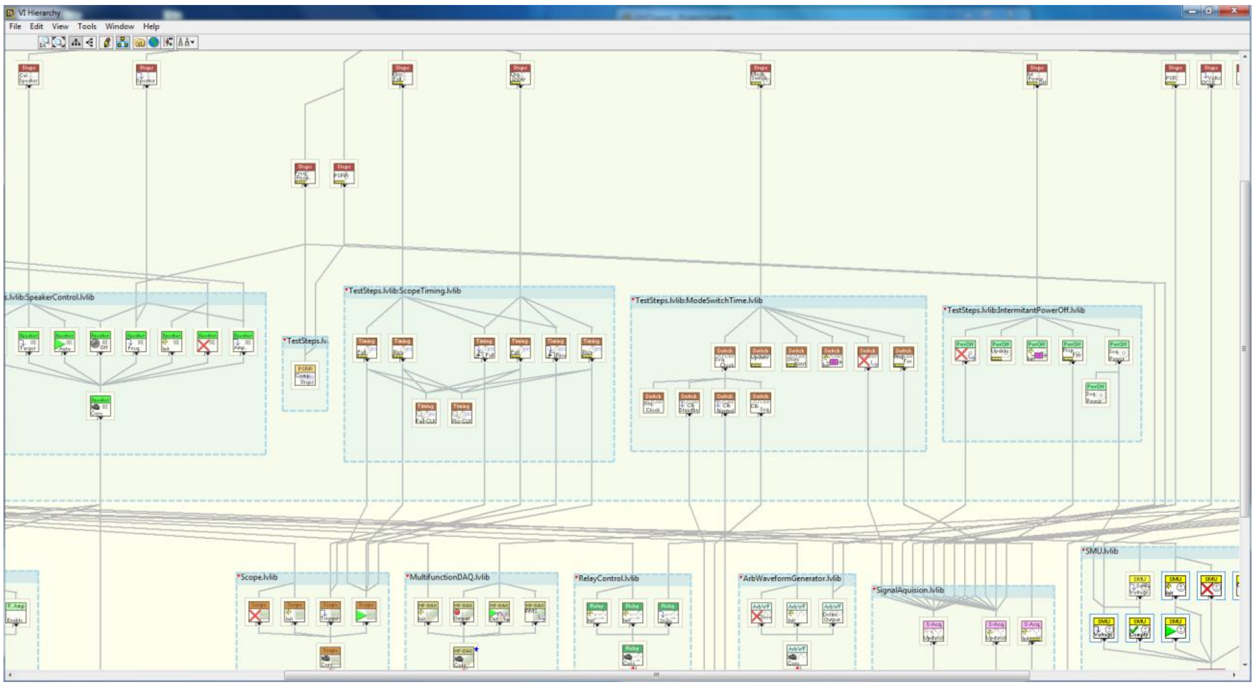

Figure 2 illustrates how libraries were used to organize the code for each modular instrument and provide abstraction layers that integrate multiple hardware devices into TestStand steps.

Strategic use of LabVIEW libraries to organize the application made it easy to understand which hardware components were involved in each step type. They also exposed a unique set of API (Application Program Interface) functions that allowed for multiple subsystems to be grouped together logically. The various steps used by TestStand were able to repeat associatedoperations, and therefore became reuse libraries that served multiple step types and are ready to drop into other steps or applications.

Many technological challenges were addressed in the development of the TestStand/LabVIEW application. These challenges were largely overcome by relying on the attributes of the modular instruments provided by National Instruments, but each instrument provided unique applicability to the tests.

SMU (Source Measure Unit)

SMUs are used to acquire the Current vs. Voltage curves of semi-conductors. Their ability to precisely control voltage and accurately measure current was ideal for the Microphone Characterization application. Both analog and digital microphones are tested to verify their behavior over a range of supply voltages, with the current draw measurement of interest to reduce energy consumption and meet current requirements in the final device. The SMU allowed the supply voltage (Vdd) to be varied as a software controlled TestStand parameter controlled over the test vector of Vdd. The precise current measurements were available over the entire automated test range.

Oscilloscope

Two common measurements associated with digital signals are “rise time” and “delay time”. The former describes how long a digital signal will take to transition from a low to a high. The latter describes how long after a clock transition the data line will be in a valid state and should be sampled. The Oscilloscope allowed flexible trigger options that could be adapted for the various Vdd's that were used. The high-speed sampling allowed for precise temporal measurements. The ability to quickly change the triggering of the scope also provided a simple method to distinguish between two DUTs sharing a single data line by changing the triggering from rising edge to falling edge.

Arbitrary Waveform Generator (AWG)
Not all of the steps types required a clean and stable Vdd. The "Power Supply Rejection Ratio" and the "Power Supply Rejection" tests required driving the DUTs with either sine waves or square waves riding on a Vdd offset. The Arbitrary Waveform Generator provided by National Instruments was found to be more than capable of providing the "noisy" signal we required while being able to provide enough current to operate the DUTs. A couple of relay state changes and the DUT were running from the AWG instead of the SMU.

High-Speed DIO (HSDIO)
The high-speed DIO module was used to provide the clock needed to drive as well as acquire the data from the digital DUTs. The HSDIO was found to be more than capable of driving the clock at rates up to 4MHz while at the same time acquiring the state of the clock and shared data line used by up to two DUTs. Digital data was acquired at 400 Mbytes/second (four bytes @ 100 MHz) continually. Due to the multiplexed data line that was shared by the two DUTs (stereo microphones) the data line had to be sensed based on BOTH the rising AND falling edge of the clock. Another challenge that the HSDIO solved by continually stream the acquired line states was the mode switching time checks that are used to determine how quickly the DUT can change for "standby mode" (used when the device is in standby and uses a slower clock to save power) and normal mode (used for high sample rates sound acquisition and high fidelity across a wide frequency range). During the Mode Switching test the built-in scripting of eh HSDIO allowed us to switch clock frequencies under a software trigger. In order to keep up with the data stream the acquired data was passed to separation logic that down sampled the data line and separated the left and right microphone data stream.

DSA-AI
The Digital Signal Analyzer-Analog Input module was used to monitor the signals for the analog microphones. The low noise of the DSA-AI allowed for extremely small noise floor measurements and gain options allowed for measuring the DC offset with the same device. The mini-XLR connectors also allowed for direct connection of the reference microphone. Once calibrated the reference microphone was used to monitor the amplitude of the test speaker.

Embedded Controller
With eight cores the CPU was able to keep up with the high data rate. The data being acquired for the digital DUTs amounted to 400Mbytes/second that was then separated into two bits streams of 4MHz each. The two bit streams were then down sample 44 KHz audio signals before being process to determine the Power Spectral Density (Sound and Vibration Toolkit) and presented graphically live as the tests were being performed. The CPU was also able to record .wav (included with LabVIEW) files of the audio signals that were saved for review by the engineering team.
In addition, the system used a Relay Driver, Multifunction DAQ, AO module and Power Amplifier to great effect.

Conclusion
Utilizing the products offered by National Instruments, a very precise and flexible test fixture was developed. This solution may be the first of its type and due the flexibility that comes with LabVIEW and TestStand it should be readily adapted as new microphone technology develops.

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