Getting the Straight Dope on Counterfeit Gold Bars

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NI Product(s) Used:
LabVIEW 2012
cDAQ-9174: 4 Slot USB CompactDAQ Chassis
NI 9234: 4-Channel- +/- 5V, 51.2 kS/s per Channel, 24-Bit IEPE C-Series Module
GRAS 1/2" Free-Field Response Microphone: 50mV/Pa

Category:
Structural and Physical Test and Monitoring
Automated Test

The Challenge
Develop and prototype a compact mobile audio signature testing system to detect counterfeit gold bars doped with tungsten rods or tungsten cores.

The Solution
Data Science Automation leveraged the CompactDAQ platform, the power of the C-Series microphone module and ease of microphone connectivity to create a simple, inexpensive mobile testing platform.

Introduction
Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined process of developing adaptive project solutions, staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and unique focus on empowerment through education and co-development.

Background
DSA was selected to implement this project for our customer due to our extensive knowledge of LabVIEW and National Instruments hardware. They were attracted to DSA by our membership in the NI Alliance Partner Program and our high number of LabVIEW certifications. A quick turn-around time was needed on the basic prototype system to validate the possibility of utilizing microphone technology to detect counterfeit gold bars.

In the recent past, the world market has been rocked by cases of counterfeit gold bars of various sizes being discovered in Great Britain and in the US in New York. The way these counterfeit gold bars were detected was through destructive means – drilling or cutting into the bars to detect subsurface material identity. Destructive testing is of course not the preferred method of counterfeit bar detection! Other counterfeit bar detection methods such as ultrasonic detection are not as inexpensive as a simple acoustic microphone test system.

Approach
The counterfeit gold bar test system developed by DSA is elegantly simple in application and practice. In this prototype design the system is manually operated. The user places the gold bar in a simple clamp system, starts the sound acquisition system and strikes the gold bar with a plastic watch hammer. The system records for the amount of time specified by the operator and then performs a simple data analysis routine to find the start of the data and the end of the data where the sound pressure falls below a minimum threshold of 0.75 Volts (15 Pa with the 50 mV/Pa rating of the microphone). The search for the end of the data is performed after reversing the array of data in order to not truncate the search at the first zero crossing of pressure in a ringing system.

NI products and LabVIEW were chosen to prototype this counterfeit gold bar detection system for their ease of integration and built-in analysis packages within the LabVIEW environment. NI made hardware selection simple with their web pages linking the microphone products and C-Series cards needed to integrate the microphone. The CompactDAQ chassis solution was another simple decision based on the criteria that the system be simple and portable without using a proprietary connection card – any PC or laptop can utilize the CompactDAQ through the use of an USB port. The 4-slot 9174 chassis was chosen for future expandability should the prototype prove useful in validating the theory of acoustic detection of counterfeits.

LabVIEW made the implementation of the system extremely easy with the DAQmx palette already configured to interface with the C-Series modules through the 9174 CompactDAQ. Prior experience with NI-DAQmx can be leveraged and familiar software architectures reused to bring the solution to completion faster. The LabVIEW Waveform Measurement palette provided all the functionality needed to analyze the data and extract the basic tone information of frequency through the use of Extract Single Tone Information VI and detection of fundamental frequency and frequency components with the Harmonic Distortion Analyzer VI.

LabVIEW also allowed the easy use of the TDMS file format to allow storing the raw data of the sound tests that can be accessed either through the LabVIEW based system or a third party product such as Microsoft Excel when coupled with the free TDMS Viewer Add-in provided by NI.

Detection of Real Gold

The prototype system proved rather quickly that the idea of counterfeit detection through the use of a microphone and striking the gold bars and recording the ringing could be used as a first line of defense against losing hundreds of thousands of dollars in a gold based transaction. Figures 1 and 2 illustrate the different pressure waveforms captured by the free-field microphone for gold bars of the same size and shape. The real gold bar of 10 oz size demonstrates a significant measurable amount of ringing when struck by the watch hammer. This is easily visually detected by the operator. There is a very strong peak of around 4100 Hz detected for the gold bar, and it was found to be the same for multiple gold bars of the same size and shape. Figure 2 illustrates the lack of ringing from a tungsten doped bar due in part to the differences in material itself, the two distinct surfaces interfacing at the gold-tungsten interface and the difference in hardness between the materials. In addition to the lack of ringing, it can be noted when the data is over plotted on the same graph that the Tungsten doped gold dataset falls below the 15 Pa minimum threshold much more quickly than the true gold bars.

Another benefit of the system designed by DSA and gained through the use of the TDMS file format is the ability of a developer to quite quickly create a file viewer to look at multiple recordings of sound data captured from known good and known bad specimens to illustrate the difference between the recorded and analyzed datasets. Figure 3 shows the plot of four datasets – with 2 known good gold bars and 2 known counterfeit Tungsten doped bars.

The counterfeit gold bars can sometimes produce fundamental frequencies close to that of the true gold bars as seen in Figures 1 and 2, but can also produce frequency components with multiple harmonics as seen in Figure 3. This system demonstrates that there are multiple ways to analyze and compare the sound pressure data from the gold bars under test:

- Detection of Ringing and Comparison of Raw Pressure Waveforms
- Detection and Comparison of Fundamental and Harmonic Component Frequencies

Conclusion

The system developed performed flawlessly and satisfied all the prototype test system requirements the customer hoped to achieve and proved the feasibility of the approach. The prototype test system proved that an affordable and portable test system could be created and used to detect the differences in gold bars through use of a microphone and a small hammer to analyze the acoustic signature of the gold bars presented in any financial transaction. The added benefit of the 9174 USB based chassis is the ruggedness and compact size of the system. The customer can easily pack the test system in any suitcase for transportation.

Contact Information

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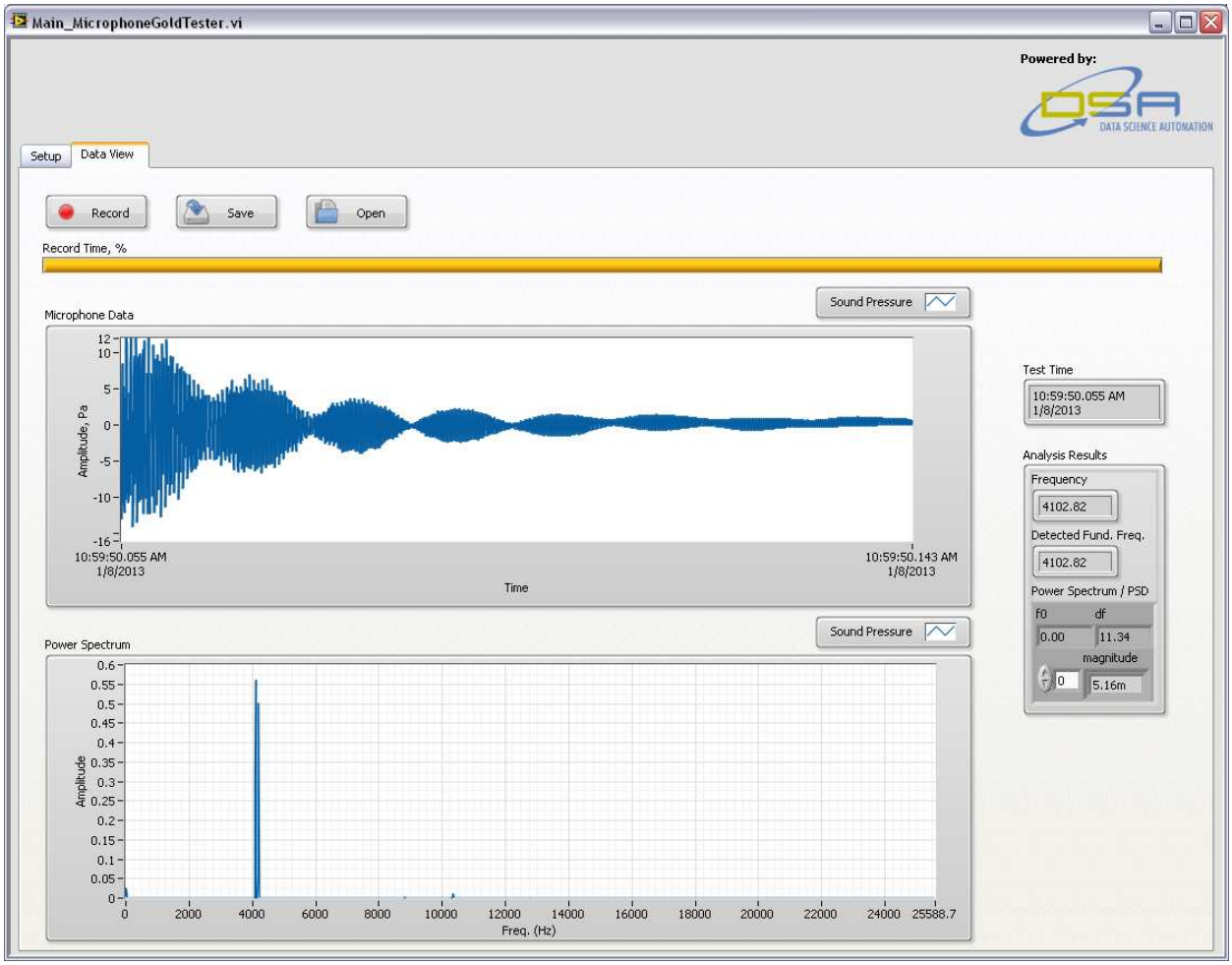

Figure 1 - Known Good Gold Bar - Ringing Evident with Strong Frequency component at ~4100Hz

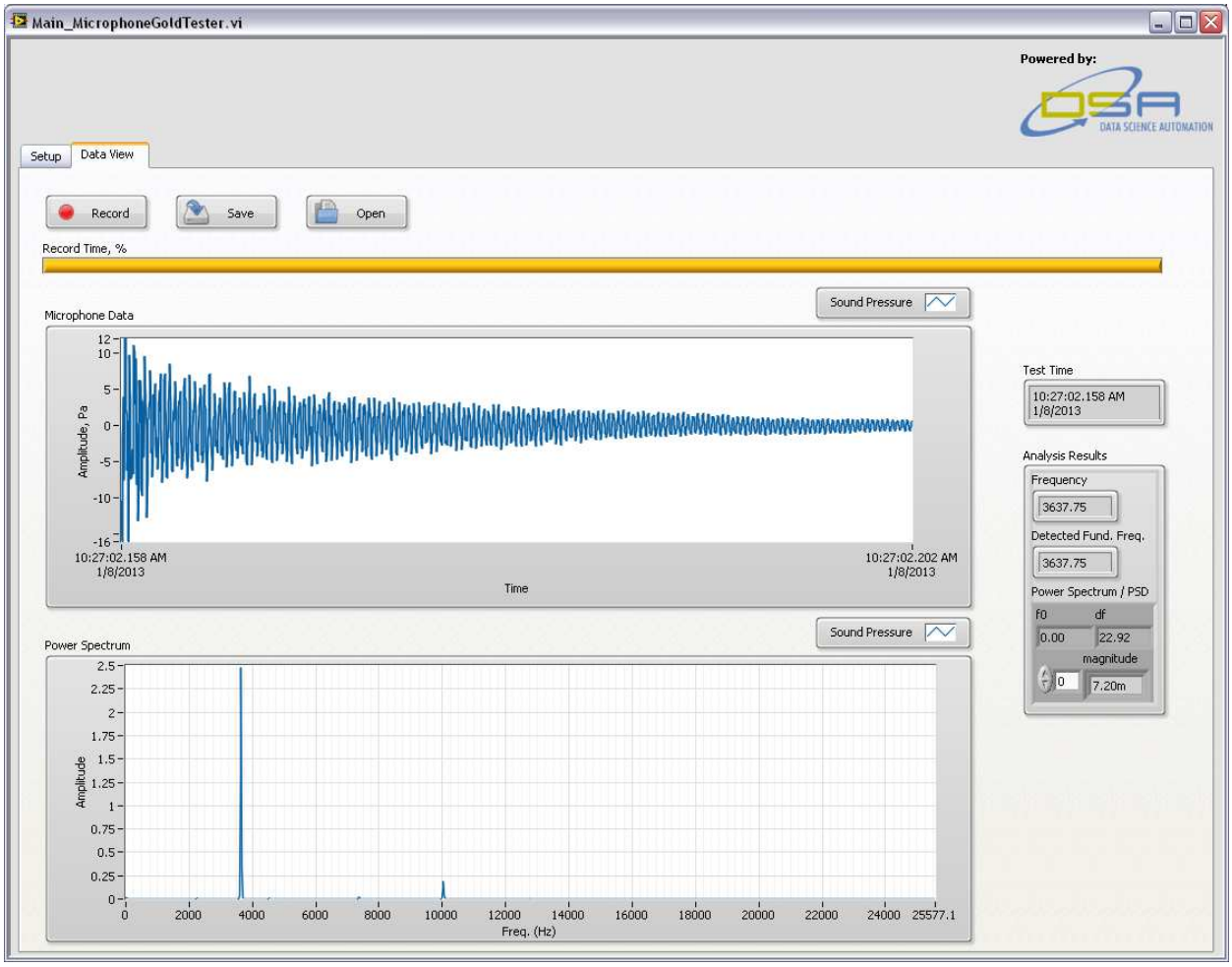

Figure 2 - Counterfeit Bar - No Extended Ringing and Frequency Detected Below 4100Hz

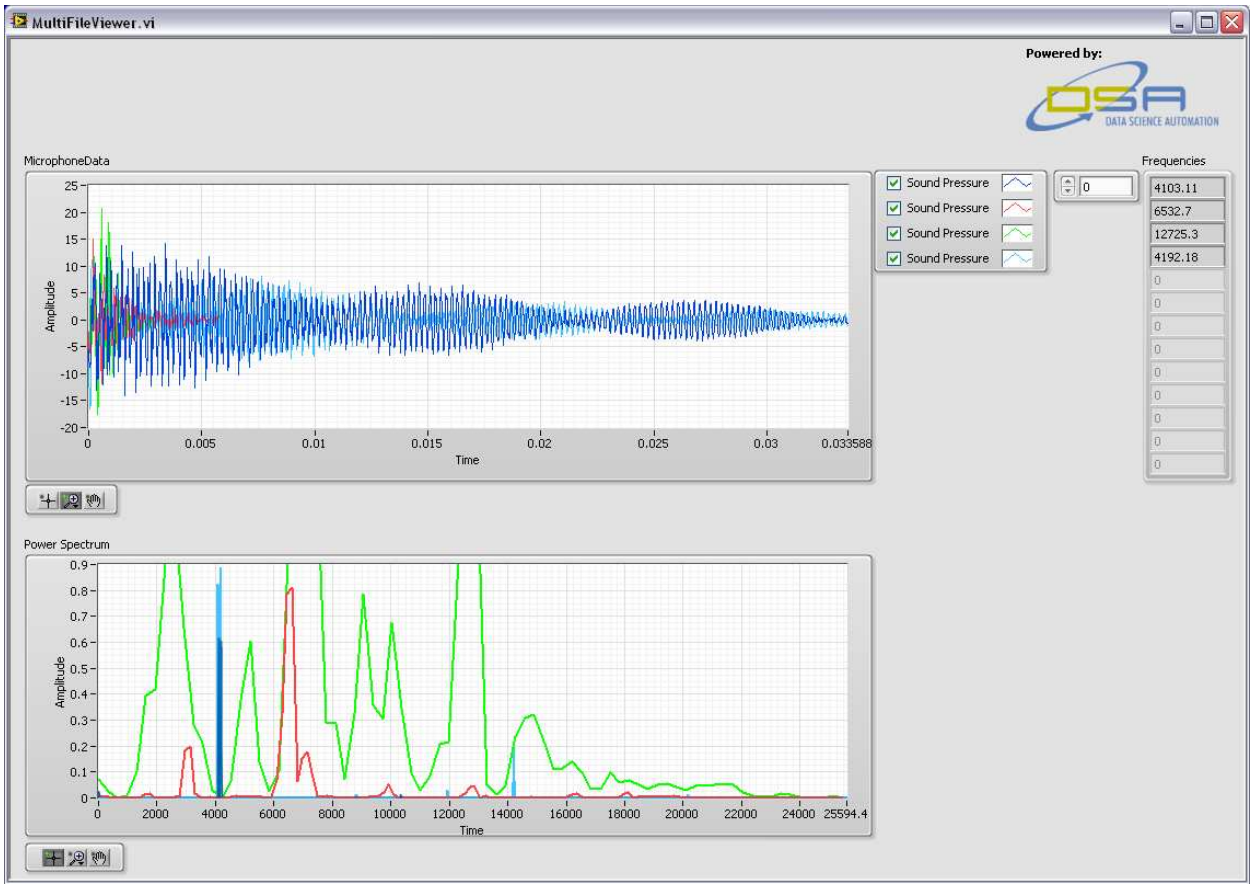

Figure 3 - Comparison of Known Good to Known Bad Gold Bars Through Use of TDMS Files