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For Automated Test, Data Acquisition, and Control Users

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Capturing and Analyzing Ultrasound Data with LabVIEW

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UE Systems Inc. in Elmsford, NY, produces ultrasonic instruments for leak detection, mechanical analysis, and electrical inspection. These instruments locate problems in industrial systems such as compressed air leaks, steam trap and valve leaks, inefficient machinery, air infiltration, and electrical emissions. UE Systems contracted Bloomy Controls to develop LabVIEW-based Virtual Spectrum Analyzer software that acquires and analyzes sound data from a sound card or WAV file. UE Systems customers use the software to analyze the spectral content of sound from industrial equipment.

Introduction

When machinery or components such as ball bearings, valves, and steam traps begin to fail, they often emit ultrasonic clunks or hisses. UE Systems detectors capture this ultrasound and downconvert it to audible frequencies so that we can "hear" it. The downconverted sound can be routed to headphones so that

the operator can monitor the ultrasound and save it to a standard WAV file for further analysis (Figure 1). UE Systems customers use the LabVIEW-based UE Spectralyzer software to understand the frequency components of the ultrasound and to document the work.

User Interface

The LabVIEW program is designed to operate as a stand-alone application. It has elements that are common to most Windows programs, such as a menu bar and a toolbar, and uses a tab control to allow the user to choose between three views: FFT, Time Series, and Parameters. The FFT tab includes a graph that displays the spectrum of the analyzed sound data, along with controls for the overlay functionality. The Times Series tab shows the raw sound data scaled to percent of full scale. Lastly, the Parameter tab includes user-

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Figure 1. UE Systems ultrasonic detector hears if a bearing is malfunctioning; Photo courtesy of UE Systems Inc.

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controllable attributes such as FFT averaging and window, sound capture parameters such as sample rate and resolution. The user sets up the properties in the Parameters tab, chooses the operating mode from the menu bar, and starts and stops the acquisition and analysis of sound data by using the buttons. Figure 2 shows the LabVIEW user interface with the FFT tab selected.

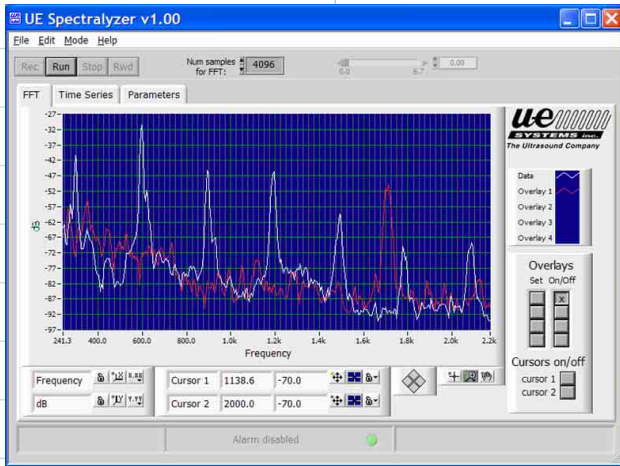


Figure 2: The UE Spectralyzer virtual spectrum analyzer user interface displays FFT trace and overlay

Basic Operation

The program has three modes of operation: Realtime, Record, and Playback. In Realtime mode, data is taken from computer's sound card and analyzed without saving for later use. In Record mode, data is taken from the sound card and stored in a preset buffer so it can be saved to a WAV file. In Playback mode, data is taken from a WAV file that is read from disk. In each mode, the data is captured in blocks whose size is determined by the "Num samples for FFT" control, set by the user. This block size corresponds to a time interval that is determined by the sample rate set in the Parameters tab (except in Playback mode, where the sample rate is read from the WAV file). This time interval becomes the program's "heartbeat" while sound data is being captured, analyzed, and displayed. For example, a block size of 1,024 samples at a sample rate of 44,100 Hz corresponds to a time interval of about 23 ms.

After being captured, data is processed in one of two ways, depending on the active tab. When the FFT tab is selected, the current data block is

routed to the FFT Power Spectrum VI, and the resultant FFT trace is plotted. If the user has overlays turned on, they are plotted along with the FFT trace. When Time Series is the active tab, the data block is graphed without processing.

Key Features

A key feature of the program is the ability to capture a snapshot of the FFT plot and store it in an overlay trace plotted along with the FFT. The overlays typically are used to compare the active trace to a baseline curve. The program can store and display four overlays by pressing the corresponding Set Overlay button. The user can save and load overlay files through menu options, enabling the user to compare the FFT from a unit under test at different points in time. The files are simple text files, allowing the user to perform further analysis offline.

Another important feature is the ability to populate the FFT graph with a set of cursors at harmonics of a base frequency. When the user clicks on the plot, the frequency value is computed. Cursors are positioned at multiples of this frequency and made visible through a property node. The program has a set of cursors predefined for use as harmonic cursors. This is in addition to the two "free cursors" that are controlled from the cursors palette.

Design Basics

Bloomy Controls created the program using a multi-loop state machine architecture. Three loops run concurrently. A data acquisition loop captures the data blocks and adds them to a LabVIEW queue structure. An event detection loop uses the LabVIEW Event structure to capture all user interface events. The main loop handles the events and dequeues the data blocks for processing.

Since the program was not written for a specific machine, it included considerable error checking to ensure rugged operation. This includes careful configuring and clearing of the sound card, clearing of arrays and graph indicators when unused, in order to save memory.

Results

The LabVIEW-based UE Systems' Spectralyzer software easily can be customized for specific customer needs and includes features unavailable elsewhere on the market. With this software, UE Systems customers can perform predictive maintenance on their machinery, conserve energy, and monitor safety and quality. ↩

To discuss your sound and vibration application, contact Rob Michell (860) 298-9925 or sales@bloomy.com.

