MEASUREMENT OF THE SPEED OF SOUND

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This experiment is meant to find the speed of sound in a convenient and elegant way.

KEYWORDS

1 Apparatus and its description

1.1 A glass or plastic tube

A glass or plastic tube of arbitrary length and diameter is used as a resonating air column.The air within vibrates when the sound source is brought near to it and stationary waves are produced.The length of the tube and diameter could be of any reasonable length, their dimensions are not important. The tube we used was 1.24 m long. At one end of the tube, we place a source of sound and at the other end a microphone.

1.2 Microphone

microphone detects the waves of sound that resonate in the air column. It converts these sound waves into voltage signals and then passes them on to the sound card.

1.3 A source of white noise

An audio file of white noise downloaded from the internet was used as a source of sound waves. We use white noise because in white noise all frequencies have the same amplitude so that a fair comparison is maintained.

1.4   Sound card

Sound card acts like a DAQ card, i.e. a data acquisition card. It acquires the analog voltage signal from the microphone, digitizes it, and sends it to the software like labview for further processing and analysis.

1.5   A software

A software such as Lab view acquires sound data from the sound card, displays the waveform of sound versus time and plots different frequencies against their amplitudes. We get a frequency spectrum.

2   General Idea

Stationary waves are produced by the white noise source in the air column of the plastic or glass tube. The air column vibrates in certain quantized frequencies only. Sound waves whose frequencies match these frequencies get amplified. For a sound wave to get amplified, it must satisfy the following relation.

$$f_n = \frac{n \times v}{2 \times L} \tag{1}$$

Where f is the frequency of the sound wave, v is the speed of sound, n is the overtone number,an integer.L is the length of the tube being used. Using this formula we can find the speed of sound. This is an easy, accurate and elegant way to measure the speed of sound.

3   Extra useful features

The good thing about this method is that it can be used to find the speed of sound in any gas, e.g. carbon dioxide, oxygen or helium etc. The method is not limited just to air.

4   Explanation of the LabView Block Diagram

The "acquire sound" VI acquires sound data from the input device which in this case is Realtek HD Audio Input. It configures the input device, acquires the task and clears the task after acquisition completes. The acquired data is displayed as a waveform graph 1, where the amplitude of the sound is plotted against time.This is shown in figure no. 1.

4.1   Configuration of the "Acquire Sound" VI

The device bar shows the sound input device we used. It was a sound card driver, Realtek HD audio input. The zero next to it shows the fact that it
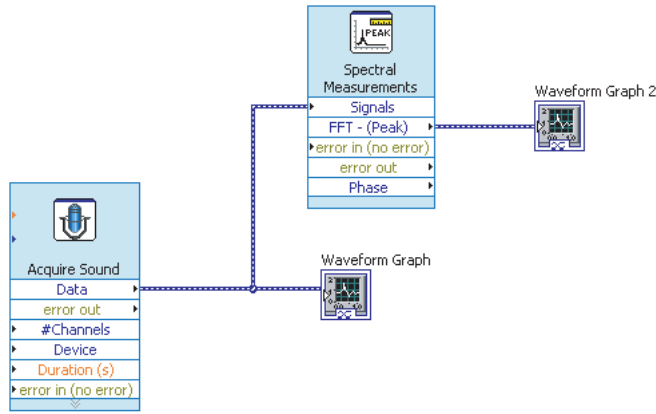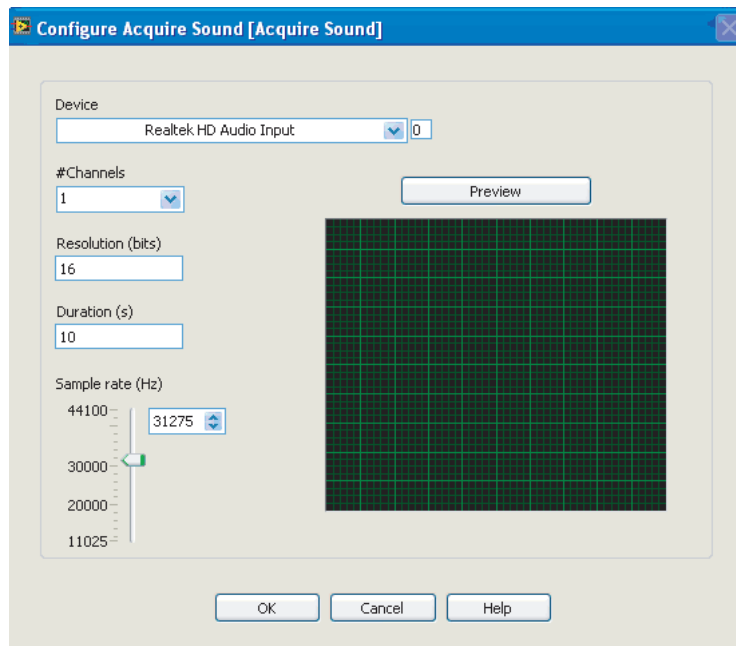
Figure 1: Block Diagram of Experiment.

Figure 2: Settings of the acquire sound VI

was inbuilt in the computer, i.e. it wasn't some device externally connected. Then comes the number of channels. Since we provided input sound through a single channel only, we set it to 1. This shows that there was no multiplexing involved. Resolution was set to 16 bits, by default. The duration bar shows that the program ran for 10 seconds from the time the 'run' button was pressed on the front panel. The sampling rate we used was 31275 samples per second.

4.2 Spectral Measurements VI

The acquired data is also fed at the same time into another VI, called spectral measurements.This is illustrated in figure no. 1. This VI performs Fourier

transform on the sound data, which is then displayed on another waveform graph 2. Here, the different frequencies of which the white noise is composed of are plotted against their respective amplitudes.
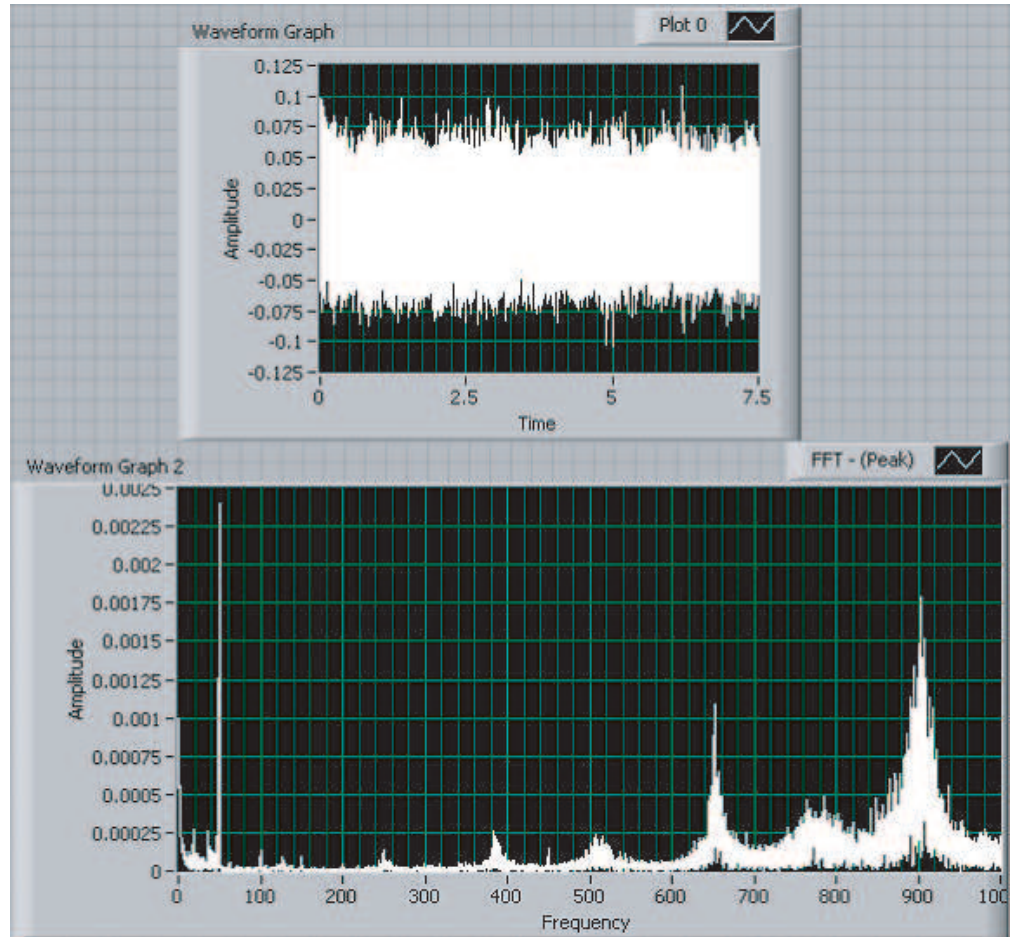
5   Explanation of the LabView Front Panel

Figure 3: The waveform graphs 1 and 2

The upper graph is the waveform graph 1, showing amplitude of sound versus time, while the lower one is the waveform graph 2, which shows different frequencies plotted against their respective amplitudes.

6   Graph Analysis

The periodically rising and falling amplitudes as we traverse right along the frequency axis show that some kind of sound diffraction is going on. The frequency spikes represent the frequencies where resonance is taking place. All these resonant frequencies satisfy the relation cited above. With first peak representing n = 1, the second peak representing n = 2, the third peak representing n = 3,

and so on. Calculating the speed of sound using the frequency of these spikes and their respective overtone numbers, we get the following values. The average

Overtone number	Frequency of the spike	Corresponding speed of sound
1	130 Hz	322.4 m/s
2	250 Hz	310 m/s
3	390 Hz	322.4 m/s
4	520 Hz	322.4 m/s
5	650 Hz	322.4 m/s
6	780 Hz	322.4 m/s
7	900 Hz	319 m/s

Figure 4: Observations

speed = 320.14 m/s. This is illustrated in Figure 4.

7 Result

The speed of sound came out to be 320.14 m/s.

8 Possible sources of errors

1. The tube was not firmly plugged at both ends. This might have hindered the formation of stationary waves to a small extent leading to low accuracy.

2. The source of white noise that we used might not be producing a perfectly pure white noise. This might have led to the observation that on the second waveform graph, different frequency spikes don't have the same amplitude.

3. The large length of the tube may also be a source of inaccuracy.

4. Some sound may be absorbed by the material of the tube, contributing to the inefficiency of the experiment.