MECH 231 Lab 2

Introduction to Measurement Systems and Signal Conditioning

The Phenomenon: An electric shaver is operated as designed. The oscillating head, driven by an eccentric shaft, produces the shaving action against the screen. As it does this, the shaver also produces vibrations, sound, moderate casing stress, heat, and electromagnetic radiation.

The Measurand: In this experiment we will measure the acceleration of the razor casing.

The Display: We wish to visualize the histories of the acceleration (acceleration versus time).

The Objective: To compare the four major types of filters and their effects on the acceleration data of the razor.

The Measurement System:

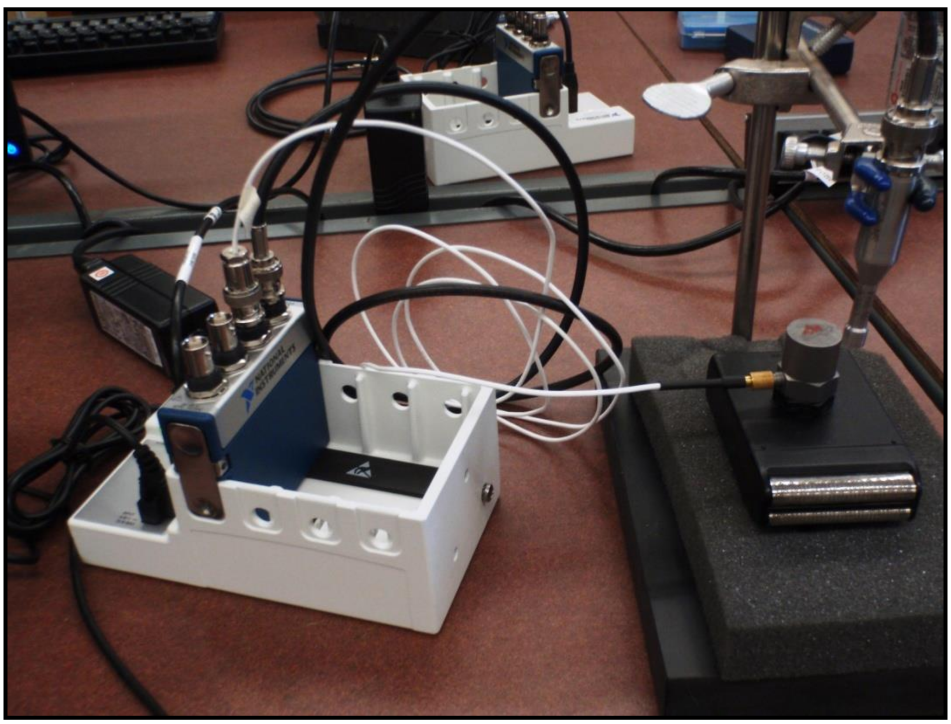

Figure 1: Photo showing all equipment used in this lab. The accelerometer is placed around shaver to acquire data, and NI chassis w/ NI 9234 module is connected to computer

Equipment:

Accelerometer - this **transducer** produces an electric signal (charge) that is proportional to the acceleration (g) normal to its base. Thus, when the accelerometer is glued to the casing of the shaver, its output (charge) is proportional to the normal acceleration of the shaver casing at that position. These are commercially available from PCB electronics (#J352C33).

NI 9234 DAQ module w/ chassis- this is a high-accuracy Analog Input data acquisition (DAQ) module specifically designed for high-channel-count sound and vibration applications.

Cables - these "coaxial" cables are especially configured to minimize sensitivity to stray charges. Since the pre-amplifiers would convert *any* charge to a corresponding voltage, we try to ensure that only *acceleration-related* charges are carried on the acceleration cable, and only *sound-pressure-related* charges are carried on the sound pressure cable. Although cables of any length act as "antennae" for stray noise, these "coaxial" cables are designed to pick up a minimum amount of noise.

Signals:

Acceleration - The acceleration history can be observed directly from the trace on the waveform graph through the created LabVIEW program.

Procedure:

Plug the accelerometer into any of the 4 channel inputs on the NI 9234 Modules using the BNC cables.

Open a new LabVIEW VI (File > New VI). Display the tools palette that you will use to create the VI. At the top of the page, select View>>Tools Palette. Repeat this and open the Functions Palette. Next, move the cursor to the top of the page and select Help>>Show Context Help. With Show Context Help on, you will see a brief description of any icon that you hover your cursor over.

Using what you learned in last week's laboratory procedure, recreate the Labview VI to acquire data. First place a while loop on the block diagram with a stop button wired to the loop's stop condition. Place the DAQ Assistant express VI (Functions Palette>>Express>>Input>>Daq Assistant) on the block diagram, and in the pop-up configuration window select Acquire Signals, Analog Input, Acceleration, and choose the correct channel for your accelerometer. Click Finish. Set the Acquisition Mode to Continuous. Change the Samples to Read to 100, and set the Rate to 2000 Hz. Note that the scaled units are in "g" (the Earth gravitational acceleration is equal to 1 g). Click OK once you have finished configuring the DAQ Assistant.
Display the data with a Waveform Chart and Numerical Indicator, and wire the data to be written to a file with the Write to Measurement File. Create a filename control for the write to measurement file express VI by right clicking on Filename>> Create>>Control. Notice that a new Filename control dialog box has been added to the Front Panel.The finished VI should appear similar to Figure 2 and contain the same components. This basic VI is the skeleton for all experimental VIs you will use in this and subsequent laboratory classes.

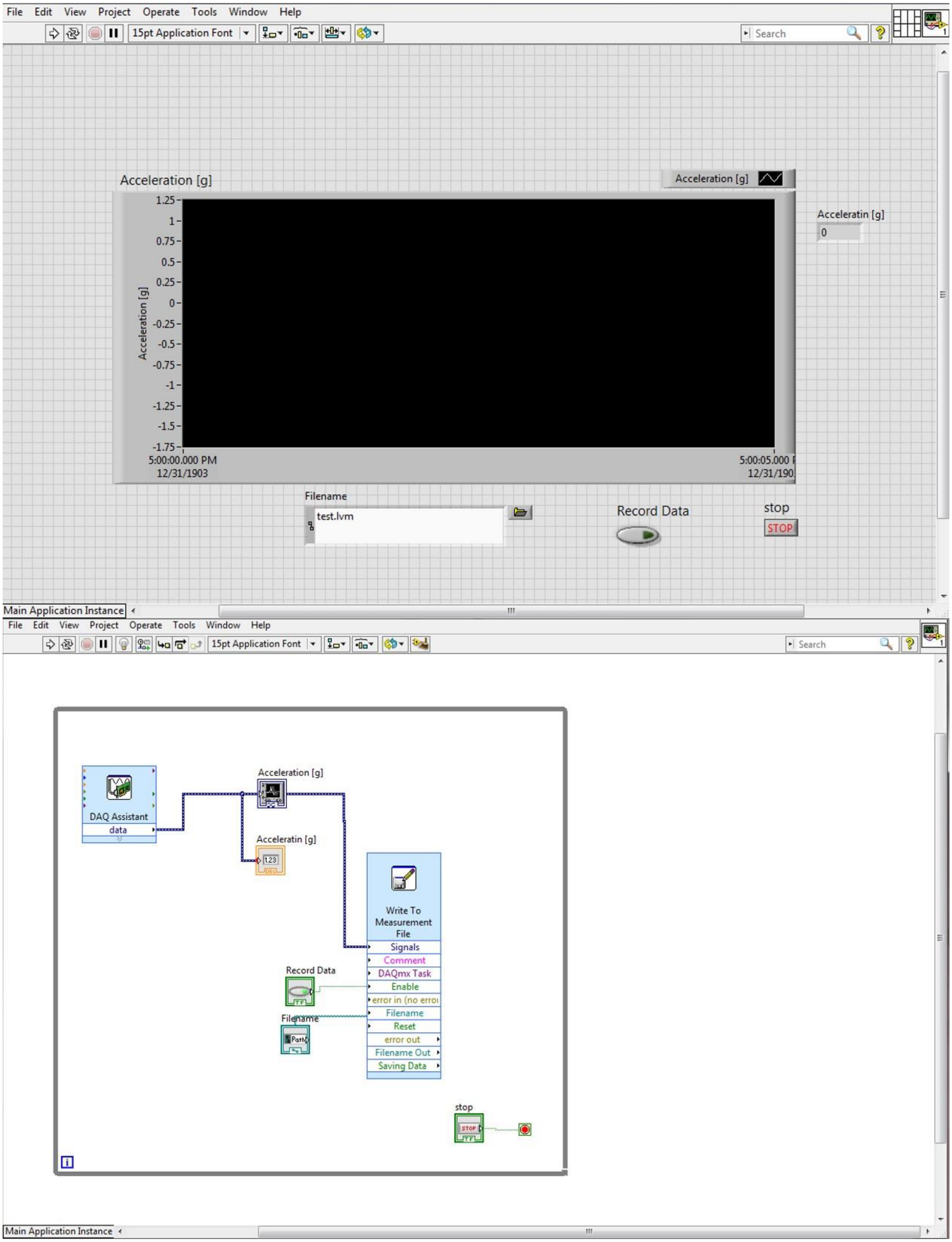

Figure 2. The LabVIEW VI utilized for this laboratory.

Attach the accelerometer to the shaver using beeswax. When ready run the program, start the shaver, and record several cycles of the acceleration waveform, then turn the shaver off.

Examine the Acceleration trace:

a. What is the period of the signal? The frequency? The amplitude? The general shape of the waveform?
b. Are there any random (not-periodic) components
c. Do you think the accelerometer's size might influence the trace? Explain.

The data collected in this step is what is called "Raw" data. That is, it has not been conditioned. Now you will filter the data to collect a "cleaner" signal. With the code turned off, navigate to the Block Diagram. Right click on the Block Diagram and select Express, Signal Analysis, Filter (Figure 3). Place the Filter express VI on the Block Diagram near the DAQ Assistant.

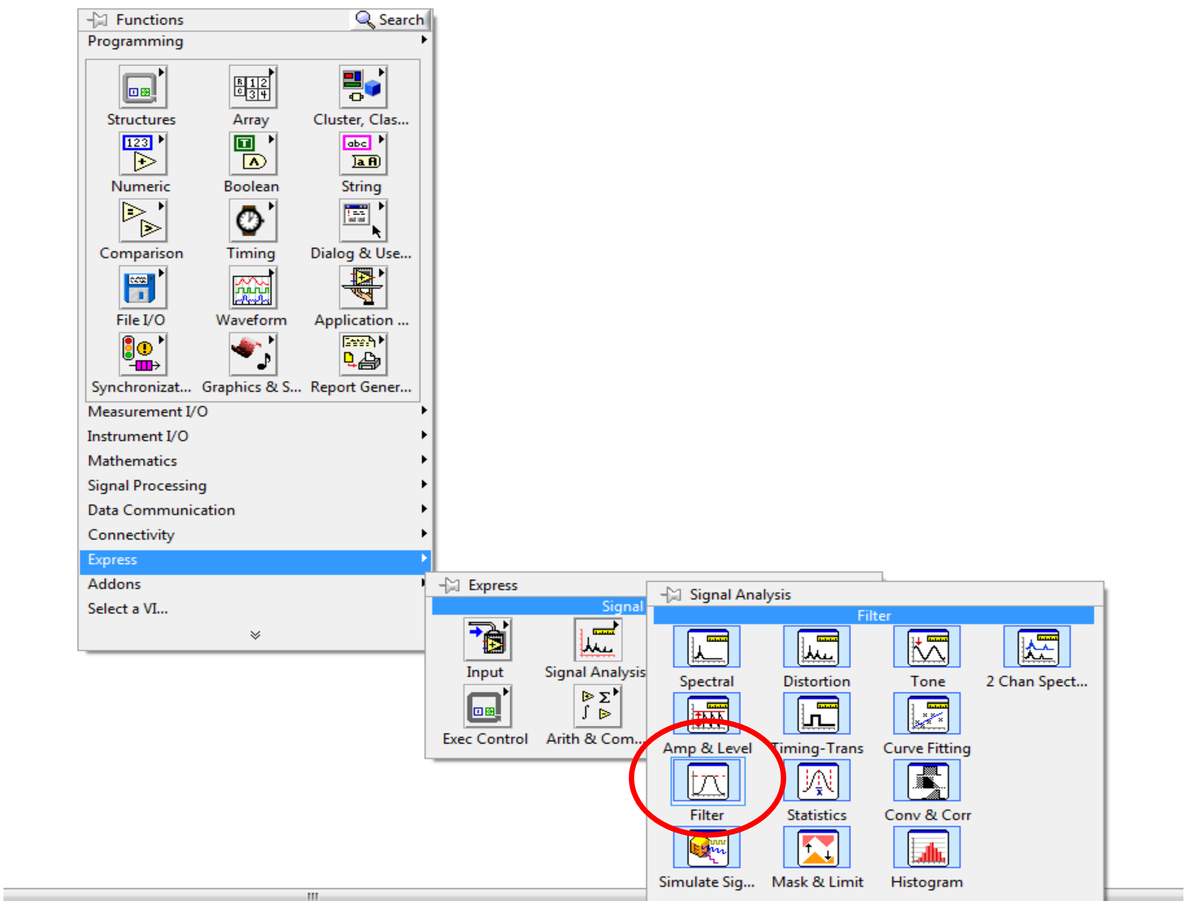

Figure 3. The location of the Filter express VI in the Functions Palette.

A new window will appear to configure the filter. Open the Filter Type pulldown menu and notice the various types of filters available for use. Select the Lowpass filter option and set the

Cutoff Frequency to 50 Hz. Use the Butterworth Topology and keep the filter Order at 3 (Figure 4). Click OK.

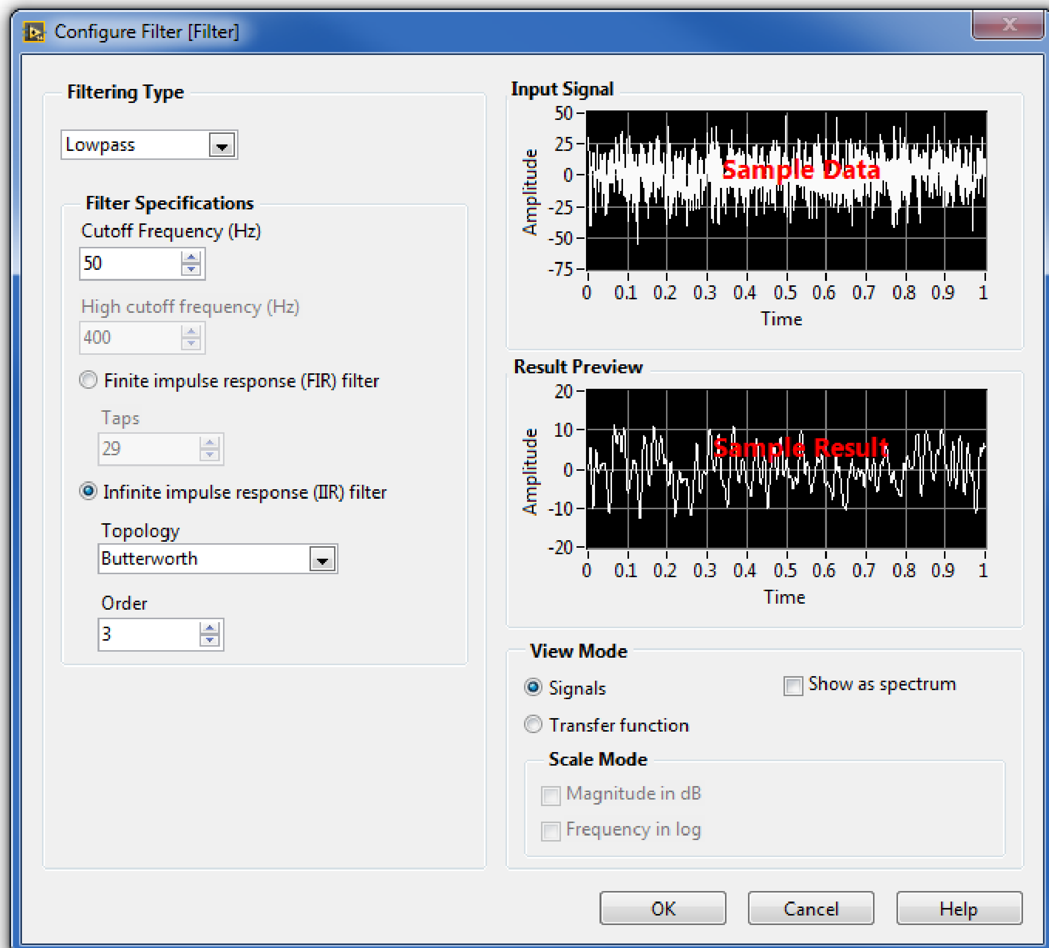

Figure 4. The Filter configuration window.

We will now run the data from the DAQ Assistant through the filter before it is displayed on the Front Panel and Written to the Measurement File. Click on the wire running from the DAQ Assistant to select it and press the Delete button on the keyboard. Now run a new wire from the DAQ Assistant into the Signal input terminal on the Filter express VI. Run another wire from the Filtered Signal output terminal of the Filter express vi and connect it to the existing wires running to the Waveform Graph and Numerical Indicator (Figure 5).

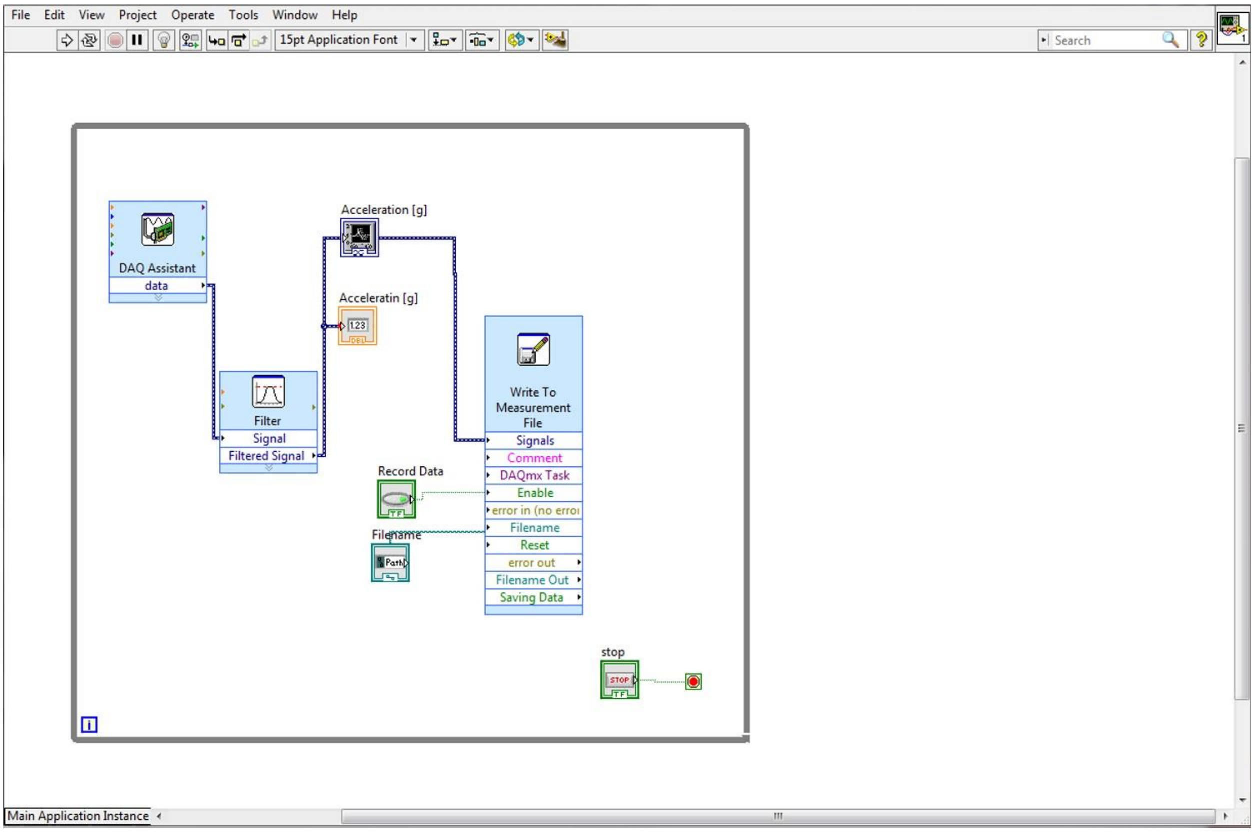

Figure 5. The new VI with the Filter express VI.

Repeat the shaver data acquisition procedure and note the effects of the filter on the acquired data.

Repeat the procedure three more times using the Highpass, Bandpass, and Bandstop filters. Do this by double-clicking on the Filter icon on the block diagram while the code is not running. Leave the low cutoff frequency at 50Hz and the high cutoff frequency at 400Hz. Collect acceleration data from the shaver for each of the filters to include in your lab report.

Items to discuss in your lab report:

- How did each filter affect the acceleration data?
- Which filter was best for the acceleration data? Why? Carefully compare the period and amplitude of the raw data to the filtered data.
- Were the cutoff frequencies appropriate for the shaver? Based on the collected data, would you propose a different set of cutoff frequencies?