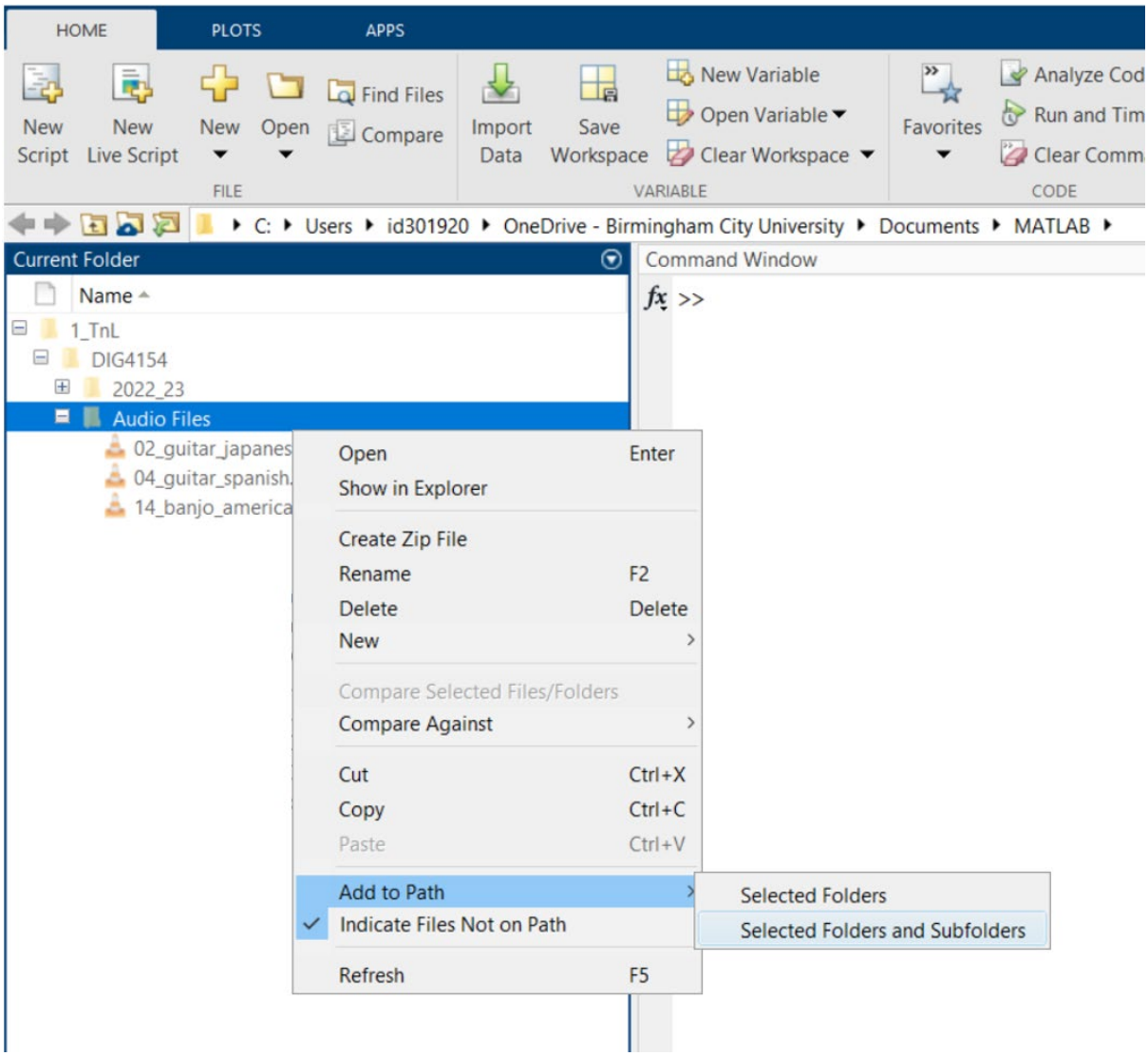
MUSICAL INSTRUMENT SPECTRAL ANALYSIS

Spectral Analysis of Acoustic Signals

Spectral analysis helps to visualise the amount of energy present at different frequencies in a signal. This is incredibly useful in audio engineering. Spectral analysis enables us to investigate the difference in high and low frequency energy between instruments playing different pitches.

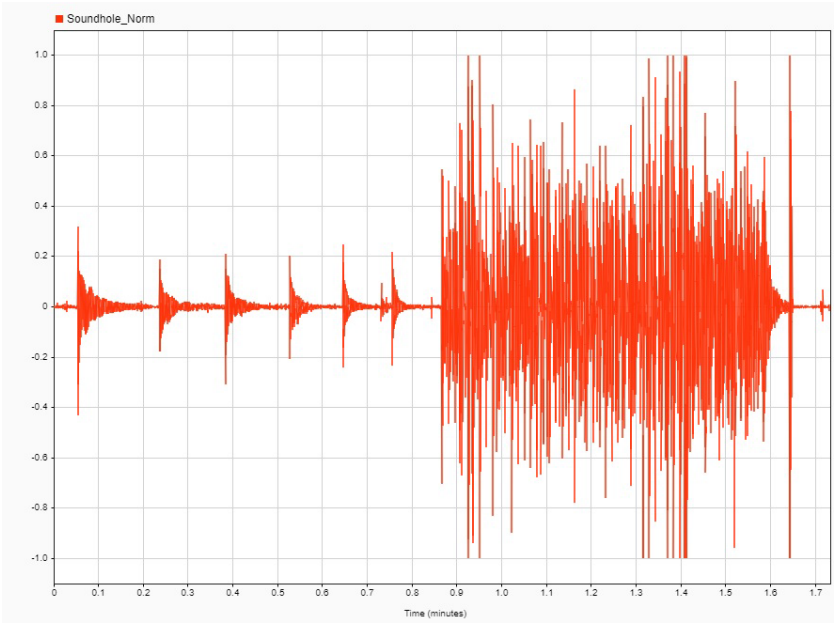
In the ATD shared folder (Audio Files Download), you will find three .wav files. Download these and save them to your MATLAB working directory (typically, 'Documents > MATLAB').

Open a new MATLAB session, and make sure the .wav files have been 'added to path'. Files and folders added to path will appear with solid black text in the file navigator pane. If the folder and associated files are shown with light grey text, right click and 'Add to Path' including 'Selected Folders and Subfolders' as shown below:

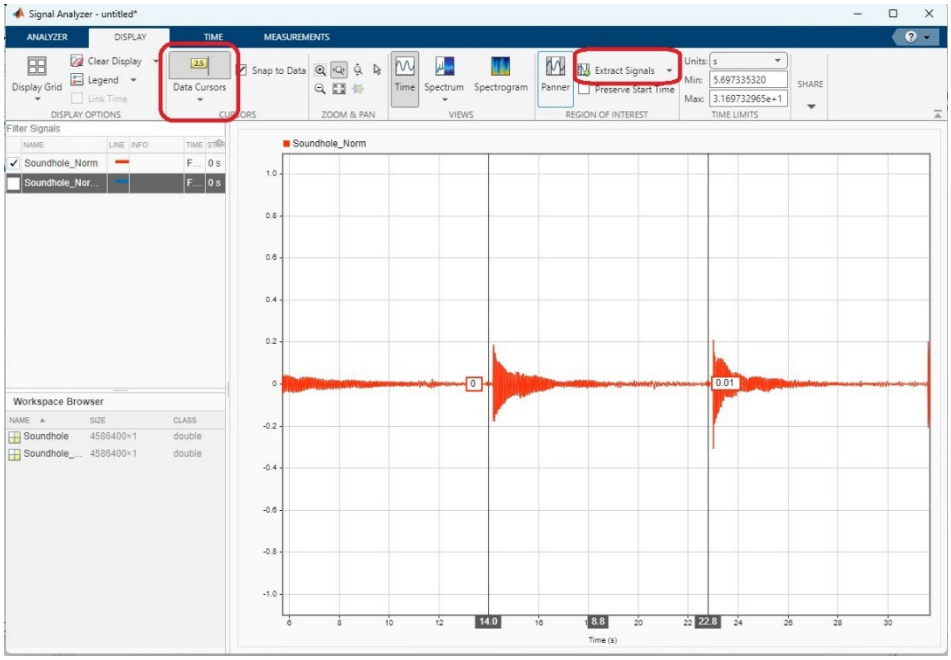


We can now analyse the spectra of the different guitar recording .wav files (Soundhole, Bridge, 12th Fret).

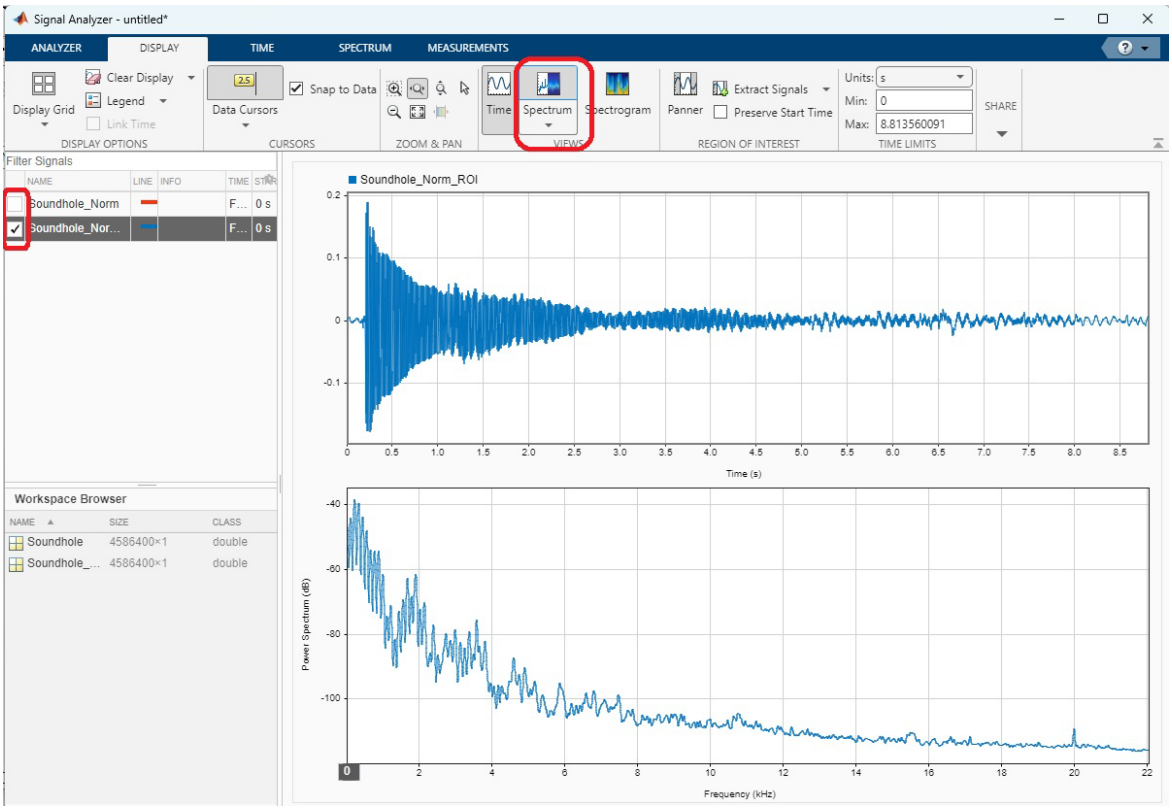
In the same folder, you will find a .m file named ‘ATD_Spectral_Analysis’. Open or copy this code into a new script and save it into your MATLAB working directory. Running this script will open the MATLAB application ‘Signal Analyzer’ and should display the Soundhole recording waveform:



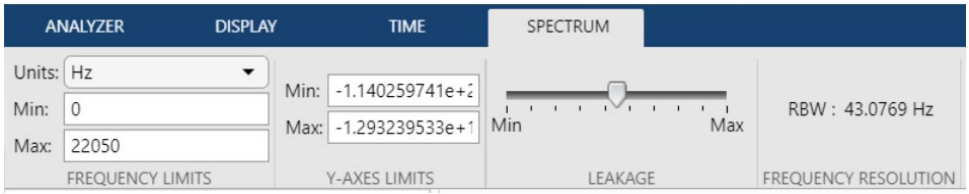
As you can see in the time domain display, we have multiple notes in the recording. Select the data cursors button (Choose 2) and highlight a note of your choice. You may have to zoom for a more precise selection. Then press the “Extract signals” button and choose “Between Time Cursors” to make a selection.



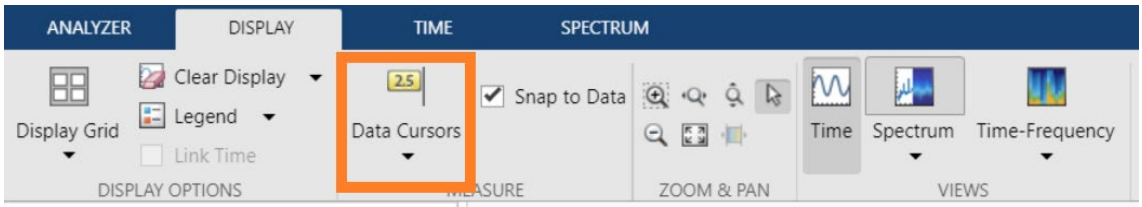
This should produce a new variable in the signals window, select this to view the segmented guitar note. Clicking the ‘Spectrum’ button in ‘VIEWS’ will calculate the FFT of the Sound hole time signal and display the spectra:



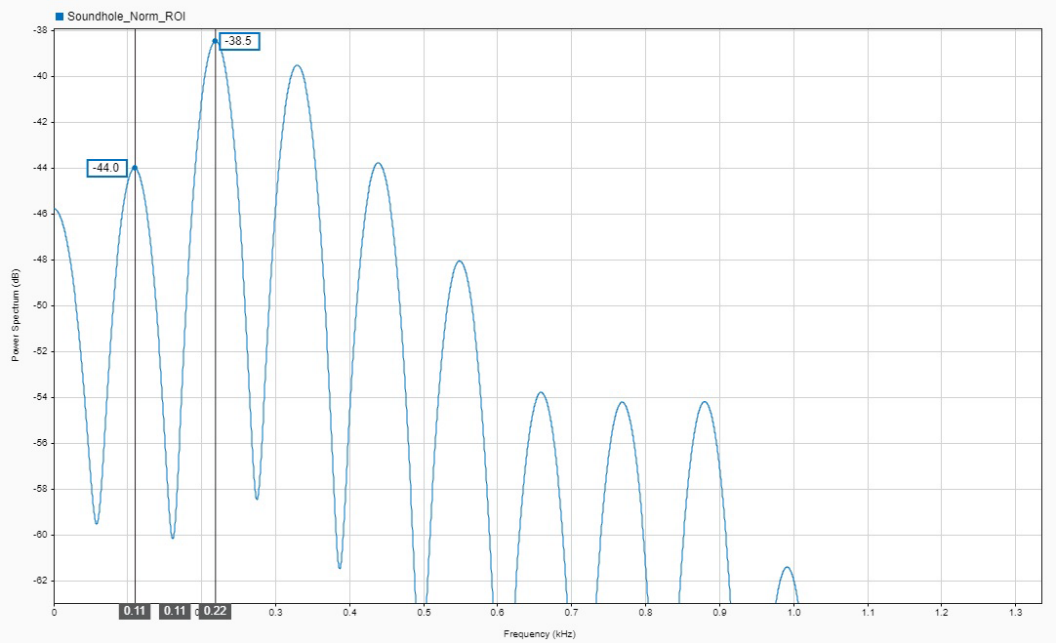
You can modify the appearance of the plotted spectrum using the features in the ‘SPECTRUM’ tab:



In the ‘DISPLAY’ tab you can use features such as ‘Data Cursors’ which will aid your analysis:



By adjusting the frequency and amplitude limits of the plotted spectrum, and using a double data cursor, we can see the fundamental frequency of the recorded note, shown by the first peak, is approximately 111Hz. We can also see the subsequent harmonics are multiples of this frequency:



Using the MATLAB Signal Analyzer, plot the spectra for the other notes, or import a recording from an alternative microphone position, and answer the questions below:

1. What are the fundamental frequencies of the individual notes played in the recording?
2. Do the harmonics of the other instrument notes also occur at multiples of the fundamental?
3. What is the upper frequency limit of each recording? Are they all the same?
4. Are there any other differences you notice between the recordings?

You may find the resources below helpful:

- MATLAB Signal Analyzer: MATLAB Help Center, Using Signal Analyzer App