Technical note on collecting spectrographic data

Until quite recently collecting spectrographic data required the type of equipment only found in serious research laboratories, with access to anechoic chambers, accelerometers, impedance heads, etc.. These days it can all be done to quite a degree of sophistication with just a home computer, a reasonable microphone, some freeware and a bit of cunning.

The major tool in the armoury is a software spectrum analyser. Some of these packages are available as freeware and come with software signal generators, timers, counters, frequency meters, oscilloscopes and a host of other features. At the time of writing my preference is for a package called Visual Analyser.

To take guitar frequency responses I set the program up to have good frequency resolution (approximately 0.67 Hz) and collect the results of 10 taps on the guitar panel which are then automatically averaged and displayed. A tap is an impulse input which excites the guitar over a very broad frequency range and is a standard industrial method of eliciting frequency response data. The display can be saved in various ways, but I save the ones I want as text files which can subsequently be read into a spreadsheet program if further analysis is required.

I just tap the guitar with a light rubber mallet made from a pencil erasure and a length of dowel and record the results into a microphone plugged into the sound card of a personal computer. There are, of course, limitations to this process but for my purposes these haven't presented a serious problem.

The major limitations are:

1) No phase data is collected as only sound pressure measurements via a standard microphone are taken. This has presented no real obstacles.
2) The amplitude of plots from one instrument to another cannot be compared because there is no standard intensity for the exciting signal (the hammer tap). This presents no real problems either because the apparent volume of an instrument (what you actually hear) bears little relationship to the average output level of the instrument! What we hear as loud instruments are those instruments with high peaks in specific places on the frequency response and these are readily apparent even with an uncontrolled excitation.
3) You need to have some idea where the plate's antinodal regions are for the modes of vibration you are interested in and then you need to tap on these antinodal regions in order to get a response from them.

It might appear that it is possible to significantly influence the relative height of various modal peaks, and that is true. For example you will get very little excitation of a cross dipole if you only tap on the centreline of the instrument. However, if you tap systematically in a reasonably constant pattern on the antinodes of the low frequency modes you will get very reproducible results. If you want to be very particular you can lay out a grid on the top of the guitar to mark the places to tap.

When I require a really detailed analysis, I take a series of 5 spectrographs, each an average of 10 taps around the antinodes, read these into a spreadsheet and plot the average of the 5. The degree of repeatability can be seen from the plot below of the spread across the 5 individual spectrographs. If you compare plots of the same guitar taken on different occasions I find that they are readily identifiable as the same guitar. Now whilst this might not satisfy a research scientist, it is plenty good enough for my needs as I am working primarily in the frequency domain and so the relative amplitude of the various plots is rarely of importance to me. It is far less time consuming obtaining data this way than setting up a frequency sweeping exciter with an accelerometer attached with the guitar in a special holding device

and suffering the vagaries of auto-correlation in the output signal due to the smooth nature of the frequency sweep. A plot such as the one in Fig.1, below (5 sets of 10 taps read into a spreadsheet and plotted) takes 7-10 minutes to complete. The wider spread around the 100-120 Hz mark is due to changing the angle of the guitar relative to the microphone so that a little more or less sound hole output has been read. The guitar is held by a person as if it were being played (i.e. no fancy holding jigs).

For most purposes it is only necessary to save the one sequence of 10 taps, which takes about 30 seconds. I found that I learned far more by studying many guitars using these techniques than I would have had I studied one or two guitars intensely using typical laboratory techniques.
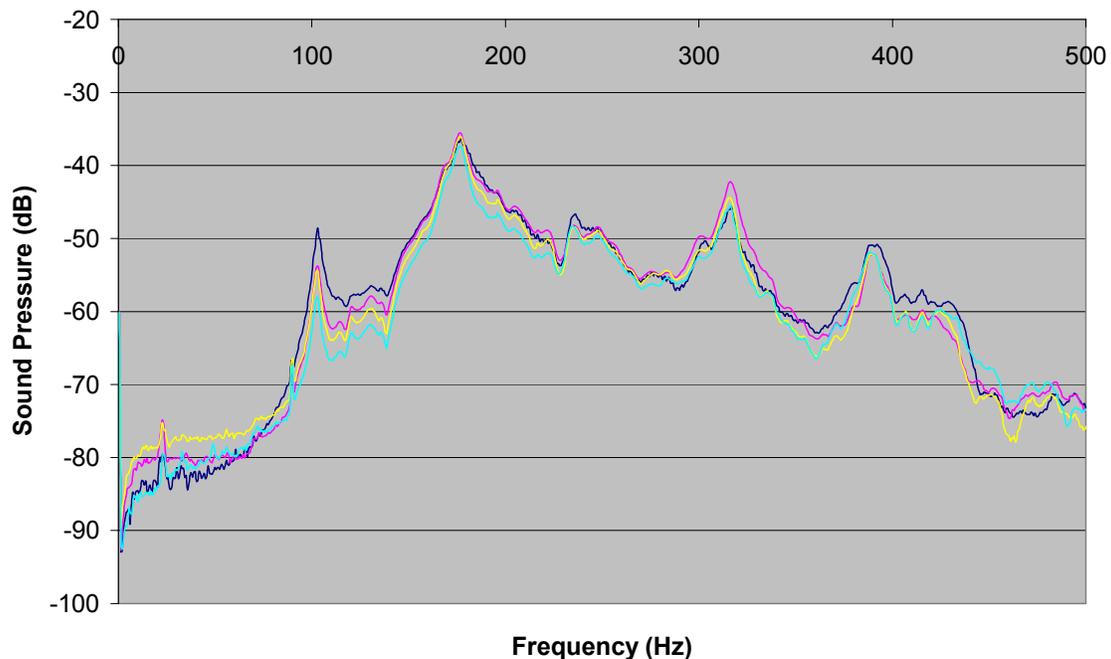

Fig. 1: Repeatability of 5 tap test plots (OO style guitar)

Typical Settings for Visual Analyser version 9.0.1

The screen shots following show the typical parameter set used to collect the data above. The spectral line resolution follows as a result of selecting an FFT size and a frequency sampling rate, Fig. 2. The maximum spectral resolution available is 0.12Hz. For the best frequency response when tap testing set the "Smoothing windows" drop down box (bottom left) to "None".

To average over 10 hammer strikes, set the spectrum averaging to 10 in the Capture Scope/Spectrum window, Fig. 3. Using the settings in Fig. 2, it takes about 1.6 seconds to collect a buffer of data, which preferably should contain just one hammer strike. Synchronise your hammer strikes with the refresh rate of the spectrum window to get the timing right. Visual Analyser will then display a window showing the frequency response plot. The data in that window can be saved from that window in a variety of formats (File menu).
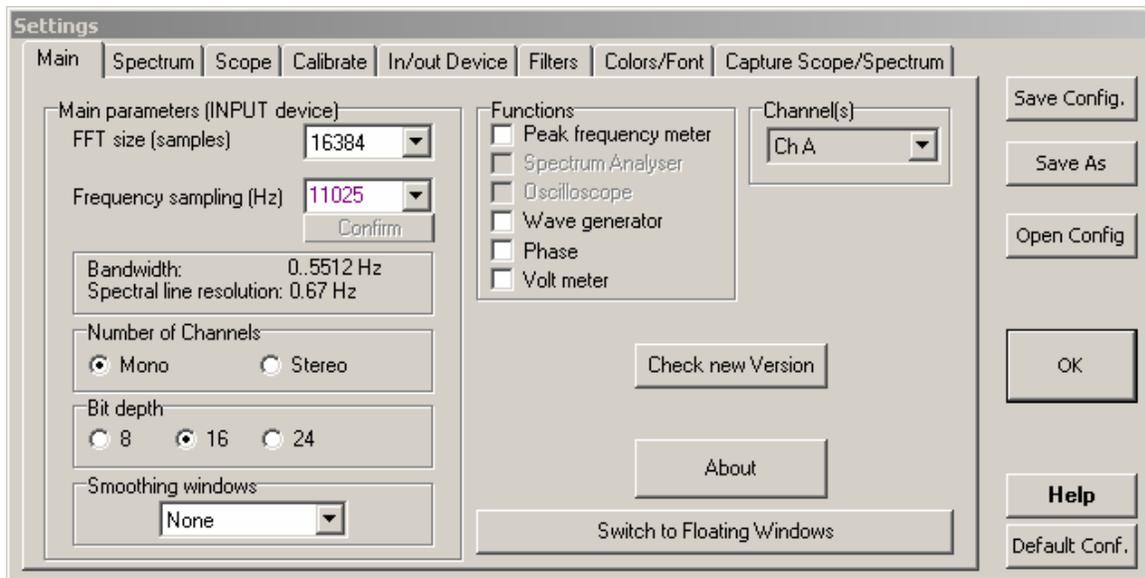
Have fun!

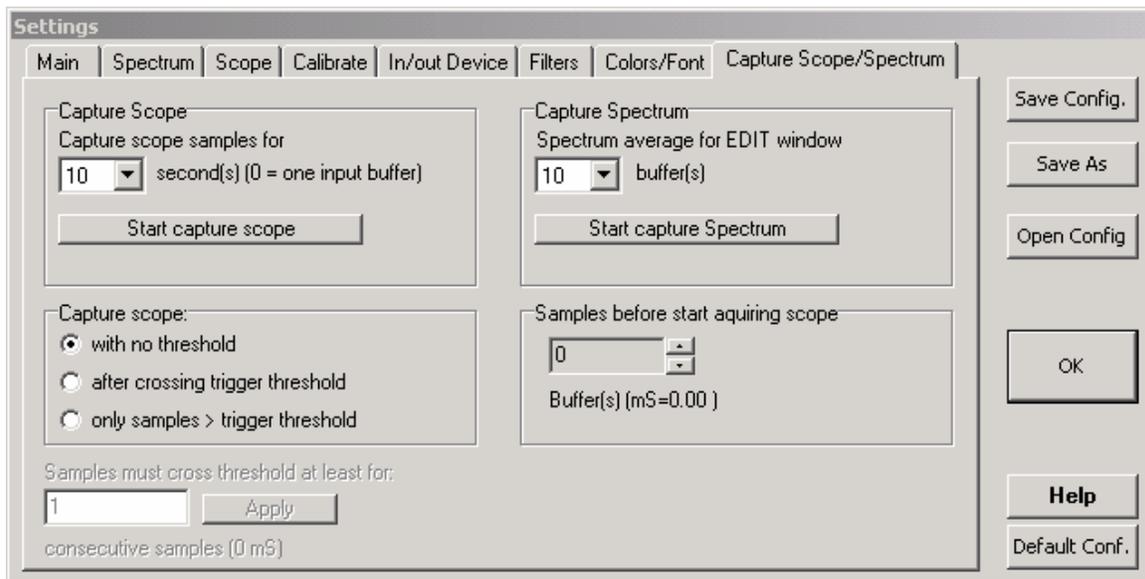**Fig. 2: Establishing the spectral resolution**

Fig. 3: Setting the number of buffers (hammer strikes) to average over