Measuring the Frequency Response of Your Audio Device

One of the most powerful tools in Electroacoustics Toolbox (FEaT) is the Dual FFT Analyzer, which is capable of measuring system transfer functions and even indicating the quality of the measurement. This tutorial focuses on using the Dual FFT Analyzer to measure the frequency response of the audio device that you use to measure other systems and devices. If you want to measure the frequency response, or impulse response, of a listening room for example, that measurement will be affected by the quality of the audio interface that you are using to make the measurement. Therefore, it is important to know how your measurements will be influenced by your audio interface.

When measuring the properties of some device, like its frequency response, that device is commonly referred to as the “device under test” or DUT. In this case, the DUT is actually the audio device that would normally be used to measure some other device or system.

Measuring Your Audio Device

1. Connect your device to your Mac (if necessary, you may want to consult your device's user guide or owner's manual).
2. Using a patch cable that is appropriate for the device you are using, connect one or more outputs of the device to one or more inputs of the same device. Figures 1 and 2 demonstrate the connections using an Echo Indigo io PCMCIA card interface and an Echo AudioFire4 FireWire interface, respectively. It is important to keep in mind that what will be measured in this tutorial is actually the combined frequency response of the input channel, the output channel, and even the patch cable between them.

Figure 1: Echo Indigo io Patch Cable
3. Launch Electroacoustics Toolbox.
4. Create a new project if one was not created automatically when the program launched.
5. Click the Device IO button in the project window's toolbar to open up the Device IO Setup window.
6. In the Device IO Setup window, click on the name of the device you would like to measure in the Available Devices list. This will display the device's properties in the lower portion of the window.
7. Make sure the nominal sample rate is set high enough to capture the desired frequency range.
8. Create a new Dual FFT Analyzer tool. This can be accomplished by clicking the “Add” button (➕) in the Dual FFT Analyzer row of the project toolbox, selecting Dual FFT Analyzer from the Tools menu in the project window's toolbar, or by selecting New Dual FFT Analyzer from the Tools menu.
9. Select the DUT from the Input Device popup menu in the signal drawer of the Dual FFT Analyzer.
10. In the Live Data Sources box, select the input and output channels corresponding to the physical channels connected in step 2. (Hold down the Command/Apple key to select multiple non-adjacent channels.)
11. In the FFT tab of the Dual FFT Analyzer's controls drawer, set the number of spectral lines to a value that will provide the frequency resolution you need. The frequency resolution of your measurement can be determined by the selected frequency span (which is dependent on the sample rate) and the number of spectral lines. You can calculate the frequency resolution by dividing the frequency span by the number of lines (if guardbanding is turned off). For example, if the selected frequency span is 24000 Hz, and the number of lines is 6000, the frequency resolution will be 24000/6000 = 4 Hz. You can also view the current frequency resolution of the analyzer inside the analyzer's info drawer, which slides out of the right-hand side of the analyzer's window.
12. Click on the Function tab of the Dual FFT Analyzer's controls drawer to set up the measurement. The number of individual measurements that appear in the Function table will be one less than the number of channels selected in the Live Data Sources box of the signal drawer (unless only 1 channel is selected, in which case they will be equal). For each input/output channel pair that is connected by a patch cable, the output channel should be selected in the Reference popup menu, and the input channel should be selected in the Source popup menu.

13. The name of each measurement can be edited by double clicking on it within the Name column of the Function table.

14. From the Function popup menu, select Transfer Function (H1) Mag to measure the magnitude of the DUT's frequency response. Figure 4 shows the Function configuration for measuring the Echo AudioFire4.

15. If you are only using one output channel of the device, you can select that channel in the output channel popup menu in the Excitation tab of the Dual FFT Analyzer's controls drawer. Then jump to step 21. Otherwise, follow steps 16 through 20 to configure as many Signal Generators as necessary to measure all the desired channels.

16. Create a new Signal Generator tool.

17. Select your DUT in the Output Device popup menu of the Signal Generator's signal drawer.

18. Select the output channels corresponding to the physical output channels that you connected in step 2. Select the first output channel in the Left Output Channel box, and the second output channel in the Right Output Channel box. If you have connected more than two output channels for a multichannel measurement, you will need to create a new Signal Generator tool for each pair of output channels to be measured.

19. Click on the Swept Sine (Chirp) tab in the Signal Generator window to display controls for establishing a frequency sweep excitation signal. Configure the swept sine generator similarly to that shown in Figure 5. The Upper Frequency should be half the selected sample rate, which corresponds to the Nyquist frequency.

20. Start the generator, either by clicking the start icon in the window's toolbar, or by selecting Toggle Tool On/Off from the Control menu (or by typing Command-R).
Go ahead and save the FEaT project now.

Create a new Meter Bridge tool.

Select your DUT in the Input Device popup menu of the Meter Bridge's signal drawer.

Start the Meter Bridge.

Make sure the Peak level type is selected in the Meter Bridge's controls, then look to be sure none of the input channels are in danger of clipping (colored red at the top of the meter bar). If any of the input signal levels are too high, reduce the level in the Signal Generator (or the Excitation tab of the Dual FFT Analyzer).

Start the Dual FFT Analyzer and your measurement will be underway. After a few seconds, the measured curve will stabilize and you can stop the analyzer. Figure 6 shows a plot, created by the Dual FFT Analyzer, which shows the frequency response of the Echo AudioFire4. The frequency response of the AudioFire4 is extremely flat between 20 Hz and 20 kHz.

Now that the frequency response magnitude has been measured, other measurements are just a menu selection away. Go back to the Function tab of the Dual FFT Analyzer and take a look at the different functions in the popup menu. All the data necessary to compute the various functions has already been acquired, so there is no need to run the analyzer again to measure the phase response. Once you have measured one of those quantities, you have essentially measured them all. All that's left to do is change the selection in the popup menu.

Capture your measurement, either by clicking the capture button in the Dual FFT Analyzer's toolbar, or by choosing Capture Data from the Control menu.

Save your project so you can review your measurement or export the data at another time.
Figure 6: Echo AudioFire4 Frequency Response