Enhanced Audio, Inc.
3600 Board Road
York, PA 17402
717-764-9240

Using DC5 or Live5 Forensics to Measure Sound Card Performance without External Test Equipment

DC5 and Live5 Forensics offers a broad suite of real time audio tools including noise reduction, audio enhancement, audio measurement and signal generation. This application note describes the use of these programs to measure the "Round-Trip" performance of a sound card without the need for any external test equipment. Although this is not the most precise way to measure the performance of a sound card, it still provides a good figure of merit so that you can compare the performance of one card to another.

This document assumes that the DC5 or Live5 Forensics software is installed and working in your system. For help with installation or to get started with the software, refer to the users guide.

Requirements:

DC5 or Live5 Forensics Software
Win 98SE, Win ME, Win 2000 or Win XP
200 MHz or faster PC with Pentium or AMD processor

Other Requirements:

Full Duplex Sound Card as the Device Under Test
Cables or Adapters to connect the two outputs (Left and Right) to the two inputs on the sound card.

Sound Card Measurements possible with this technique

Noise Floor: A/D by itself (D/A – Inferred from Round Trip measurement)
Frequency Response: (Round-Trip only)
Total Harmonic Distortion: (Round-Trip only)
Anti-Aliasing Brick Wall Filter Performance

Basic Theory

Since two instances of Diamond Cut DC5 or Live5 Forensics can be run simultaneously on a computer, one instance can be used as a stimulus and the other as a measurement response to the behavior of a Device under Test, in this case a Full Duplex sound card. No external test equipment is required for the abovementioned measurements using this method other than the appropriate cables required to connect the sound card outputs to its inputs. This technique makes most of its measurements in a "round-trip" manner, meaning that both the D/A and A/D are measured simultaneously and cumulatively and the differences in performance between the two converters cannot always be distinguished from one another. This method cannot discriminate between the Total Harmonic Distortion of the D/A from the A/D. However, the Noise Floor of the A/D alone can be measured using this method. Lastly, you can evaluate the Anti-Aliasing Brick wall filter performance of the D/A's and A/D's. Since no sound card produces 0 % THD, then a signal within the frequency response of a sound card can produce products well above its sample rate / 2 value. The degree of attenuation of these high frequency products is determined by the performance of the sound card anti aliasing filters. Their job is to prevent signal distortion products from producing wrap around aliasing signals from being heard. This aspect of sound card performance can be evaluated implementing steps 7 and 8.

Process Overview

The overall measurement process can be broken down into a few basic steps. One or all of these tests may be performed. They are as follows:

1. Making the Connections (Connecting the Analog signals together on the sound Card)
2. Calibrating the Recording Gain of the input side of the Sound Card
3. Measuring the Noise Floor of the Round-Trip (D/A & A/D)
4. Measuring the Noise Floor of the A/D by itself
5. Measuring the Frequency Response of the Round-Trip
6. Measuring the %THD Round-Trip
7. Evaluating Heterodyning products
8. Evaluating D/A and A/D Anti-Aliasing Filters Performance

These procedures assume that the software and sound card drivers are up and running on your computer.

1. Making the Connections

Connect the Left Input on your sound card to the Right Output and the Right Input to the Left Output. Note that inputs and outputs are intentionally cross-wired. Some sound cards use

1/8 inch stereo mini phone jacks. Usually, these are connected to your audio equipment via cables with 1/8 inch stereo mini phone jacks on one end and RCA male plugs on the other. You local electronics store will have inexpensive RCA male-to-male converters so that you can interconnect the soundcard outputs and inputs. If you are testing a higher end sound card, you may be dealing with ¼ inch TRS (Tip Ring Sleeve) type jacks. In that case, you will need to purchase 4 cables to connect the respective inputs to the respective outputs of the card. To realize the full performance of TRS, it is important to maintain the integrity of the fully differential capability of TRS. Do not convert a TRS system it to a single ended system for the measurement process as it will compromise it, especially if you expect to observe something close to the advertised performance level of the card under test

2. Calibrating the Recording Gain

Launch the Diamond Cut software program. We shall refer to this as Instance One for the remainder of the discussion. Instance One will be our Test Stimulus. Perform the following procedure:

1. Go to the Edit/Preferences/Soundcard menu, and set up the output device to be the
   i. Soundcard under test.
2. Bring up the Make Waves Generator found under the Edit menu
3. Set the Generator to the following parameters:
   i. Frequency: 1 KHz
   ii. Amplitude: 0 dB Peak
   iii. Length: 60 Seconds
   iv. File Type: Stereo
   v. Sampling Rate: Desired Value or no less than 44.1 KHz
   vi. Waveshape: Sine
   vii. Resolution: Desired Value or no less than 16 bits
4. Click OK on the Make Waves Generator
5. The 1 KHz Waveform will be displayed after a moment or two in the Source Display
6. Click on "Looped Play"
7. Minimize Instance One of the Diamond Cut program.
8. Launch another Instance of the Diamond Cut program.
9. Go to the Edit/Preferences/Soundcard menu, and set up the input device to be the Soundcard under test.
10. Click on the Record Button, and put the recorder in Record – Pause.
11. Bring up the control panel for your sound card, and go to the Recording options and adjust the Line input until the VU meters on the Diamond Cut recorder are just touching on 0 dB. Also, while you are in this panel, be sure that all other inputs are turned off.
12. You are now done calibrating the system and ready for the testing phase.

3. Measuring the Noise Floor of the Round-Trip (D/A & A/D)

1. Un-minimize the First Instance of Diamond Cut.
2. Stop the Looped Play function
3. Go to the Makes Waves Signal Generator, and set it up as follows:

   a) Frequency: 0.01 Hz
   b) Amplitude: -97dB Peak
   c) Length: 600 Seconds
   d) File Type: Stereo
   e) Sampling Rate: Desired Value or no less than 44.1 KHz
   f) Waveshape: Sine
   g) Resolution: Desired Value or no less than 16 bits

4. Click OK on the Make Waves Generator
5. A "null set" waveform should present itself after a few moments of calculations
6. Highlight the Entire Wavefile
7. Find the Mute button under the Edit menu, and apply it to the Wavefile
8. Click on the play looped button, and you should see the cursor begin to move.
9. Minimize the First Instance of Diamond Cut.
10. Bring up the Second Instance of Diamond Cut
11. Put it in Record mode and record for 60 Seconds.
12. Save the resultant file as **Noisefloor.wav**
13. Open the **Noisefloor.wav** file in the Second Instance of Diamond Cut.
14. In the View Menu, bring up the Spectrum Analyzer.
15. Set the Spectrum Analyzer Paramaters as follows:
    a) FFT Size: 4096
    b) Freq Resolution: 10.77 Hz
    c) Range: 100 dB
    d) Bar Mode
    e) Window Type: Kaiser Bessel
    f) Display Mode: Slow
16. Click on Play Looped.
17. Let the waveform build on the Spectrum Analyzer for about 30 Seconds.
18. Click "Hold" on the Analyzer.
19. The result that you see is the noise floor of the Round-Trip journey of your sound card, except for the artifact on the left hand side of the screen. This spike is an artifact of the FFT and is meaningless.
20. You can take a picture of the Round – Trip noise floor performance by using the Print Screen function.

4. Measuring the Noise Floor of the A/D by itself (optional step)

1. Stop the playback on the Second Instance of Diamond Cut.
2. Disconnect the Left and Right Input Jacks from the Sound Card Output
3. Terminate each Input with a 100 Ohm Resistor
4. Put the Second Instance into Record Mode and record for 60 seconds.

5. Save the resultant file as **Analogtodigitalconverter.wav**
6. Open this file in the Source window of the Second Instance of Diamond Cut.
7. With the Spectrum Analyzer set to the same settings as before, and the lower right hand button clicked to the Run rather than the Hold position.
8. Click on "Looped Play."
9. The result that you now see is the noise floor of the A/D converter of your sound card by itself.
10. You can take a picture of this waveform using the Print Screen Function.
11. The D/A Converter performance is approximately the difference between the two graphs that you have printed.
12. Disconnect the Input terminating Resistors.
13. Connect the two sound card inputs back into the sound card outputs.

5. Measuring the Frequency Response of the Round-Trip

1. Minimize the Second Instance of Diamond Cut and Maximize the First.
2. Stop the Looped Play function.
3. Go to Make Waves
4. Set up the Generator in the Following manner:

   a) Frequency: Not Applicable
   b) Amplitude: -10 dB Peak
   c) Length: 600 Seconds
   d) File Type: Stereo
   e) Sampling Rate: Desired Value or no less than 44.1 KHz
   f) Waveshape: Random
   g) Resolution: Desired Value or no less than 16 bits

5. Click OK and the resultant random noise file will ultimately present itself in the Source window.
6. Click on looped Play
7. Minimize the first instance of Diamond Cut and Maximize the Second Instance.
8. Click on the Record function and record 60 Seconds on the noise file being played by the Generator in Instance One.
9. Save this wavefile under the name of **Testwhitenoise.wav**
10. Bring this wavefile into the Source window.
11. Bring up the Spectrum Analyzer.
12. Set it up with the following parameters:

    FFT Size: 4096
    Freq Resolution: 10.77 Hz
    Range: 20 dB
    Bar Mode
    Window Type: Kaiser Bessel
    Display Mode: Averaging

13. Play the wavefile
14. Let it average for about 45 Seconds and then put it on Hold.
15. The resulting graph is the Round – Trip Frequency Response of your Sound Card

6. Measuring the %THD Round-Trip

1. Stop the Play function on the second instance of Diamond Cut.
2. Maximize the First instance of Diamond Cut, and bring up the Make Waves Generator
3. Set the Generator for the Following Parameters:

   a) Frequency: 1 KHz
   b) Amplitude: -1 dB Peak
   c) Length: 60 Seconds
   d) File Type: Stereo
   e) Sampling Rate: Desired Value or no less than 44.1 KHz
   f) Waveshape: Sine
   g) Resolution: Desired Value or no less than 16 bits

4. Click on OK, and the waveform should appear in the Source Window.
5. Click on Looped Play
6. Minimize the First Instance and Maximize the Second Instance of Diamond Cut
7. Bring Up the Recorder function and be sure that it is not overloading. If it is, go to the sound card control panel and bring down the gain just a tad until there is not more clipping.
8. Record this waveform and then name it **Distortion.wav**
9. Bring **Distortion.wav** up in the Source window.
10. Bring up the Spectrum Analyzer and set it up in the following manner:

    FFT Size: 4096
    Freq Resolution: 10.77 Hz
    Range: 100 dB
    Bar Mode
    Window Type: Kaiser Bessel
    Display Mode: Fast
    Show Peak: Check (order dependent)
    Show THD: Check (order dependent)

11. Click on Play Looped.
12. You will see the "THD = _______%" displayed
13. You must give the system a few seconds to stabilize on the final value.
14. Write down the steady state number. Call it THD_m
15. Perform the following calculation:

    Sound Card %THD = ((THDm)^2 – (THDg)^2))^1/2

    THDg = 0.84 % for 8 bits
    THDg = 0.0033 % for 16 bits
    THDg = 0.0008 % for 20 bits
    THDg = 0.00025 % for 24 bits

7. Evaluating Heterodyning Products

1. Maximize Instance 1 of the Diamond Cut software.
2. Go to the Make Waves Generator

3. Set it up as Follows:

   i. Check the "Linear Sweep" Checkbox
   ii. Set the Frequency for 20 Hz
   iii. Set the Stop Frequency for 20,000 Hz
   iv. Set the Amplitude for 60 Seconds
   ii. Waveshape: Sine
   v. Resolution: Desired Value or no less than 16 bits

4. Click on OK.
5. Listen to the resultant wavefile by clicking on the play button. You should hear a very clear sweep in frequency from 20 Hz to 20 KHz. If you hear another sweep going on of less loudness and lagging behind the first sweep, your sound card is producing heterodyning products. Good sound cards should not do this, as it is a form of inter-modulation distortion.
6. Stop the play at the end of the entire sweep and bring up the Spectrum Analyzer. Set it as Follows:
   FFT Size: 4096
   Freq Resolution: 10.77 Hz
   Range: 100 dB
   Bar Mode
   Window Type: Kaiser Bessel
   Display Mode: Fast
   Show Peak: Check
   Show THD: Uncheck
7. Click play again, and note that the source signal consists of one spike which moves from the right hand side of the graph to the left. Note that there are almost no spurious signals down near the noise floor. This is the spectral content of the reference signal exciting your sound card.
8. Stop the Playback and then put Instance One of Diamond Cut in play looped.
9. Bring up the second instance of Diamond Cut and put it in Record mode
10. Record two minutes worth of the file being played.
11. Save it as **Sweptsine.wav**
12. Bring **Sweptsine.wav int**o the Source window
13. Bring up the Spectrum Analyzer and set it up in the following manner:
    FFT Size: 4096
    Freq Resolution: 10.77 Hz
    Range: 100 dB
    Bar Mode
    Window Type: Kaiser Bessel
    Display Mode: Fast
    Show Peak: Check
    Show THD: Uncheck
14. Play the **Sweptsine.wav** wavefile while watching the Spectrum Analyzer
15. A very high quality sound card will display a signal similar in noise floor as it sweeps as you observed in step 7. A low quality sound card will have lots of extra heterodyning spikes dancing around above the noise floor as the signal sweeps.

8. Evaluating Anti-Aliasing Filters Performance

1. Bring up the First Instance of Diamond Cut.
2. Set the Make Waves Generator as Follows:
   i. Frequency: 22000 Hz
   ii. Amplitude: -3dB Peak
   iii. Length: 60 Seconds
   iv. File Type: Stereo
   v. Sampling Rate: Desired Value or no less than 44.1 KHz
   vi. Waveshape: Sine
   vii. Resolution: Desired Value or no less than 16 bits

3. Click OK and then put the wave file in Play Looped mode
4. No sound should be heard from your loudspeakers (unless you are a dog!) Low quality sound cards will produce spurious sounds under this condition in the audible range. High quality cards will not. If you hear spurious signals present, this indicates a deficiency in the Anti-Aliasing brick wall filters in the D/A portion of your sound card.
5. Minimize this First Instance of Diamond Cut.
6. Bring up the Second Instance and Record the signal for about 60 Seconds at a level of – 3 dB.
7. Save the Wavefile under the name **22KHzSine.wav**.
8. Open **22KHzSine.wav** in the Source Window
9. Open up the Spectrum Analyzer and set it as follows:
   FFT Size: 4096
   Freq Resolution: 10.77 Hz
   Range: 100 dB
   Bar Mode
   Window Type: Kaiser Bessel
   Display Mode: Fast
   Show Peak: Check
   Show THD: Uncheck
10. Play the **22KHzSine.wav** wavefile
11. Still, nothing should be heard from your loudspeakers. If you do hear any spurious signals, you will also see them appear on the Spectrum Analyzer. This shows a deficiency in the %THD performance of your sound card coupled with its Anti-Aliasing brick wall filters.