Detecting Changes in Audio Signals by Digital Differencing

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Motivation

The Hi-Fi industry’s proclivity to discover new types of distortions ...and products to fix them

- premium capacitors
- cables, wires, power cords
- special amplifiers
- connectors
- vibration isolators, CD demagnetizers
- other ‘tweaks’
Controversy

Are listeners actually hearing differences?

How can you be sure what is heard?

Is there always anything to hear?

Subjectivist

“I know what I hear”, “you should trust your ears”

Objectivist

If not demonstrated in blind tests = “placebo effect”
Isolate differences by subtracting

1. Make a reference recording
2. Change something in the audio system
3. Make another recording to be compared to the first
4. Align the recordings
5. Subtract one from the other
6. Listen to what is left: the difference
Difference Tests

**Analog differencing**: Baxandall (1977), Hafler (1986) “null tests”
- done in real time
- compared simultaneous signals
- results not easily distributed

**Digital differencing**: Dunn and Hawksford (1991)
- done with digital recorder and a CD player source
- removes time constraints on signals or processing
- allows for DSP equalization of response effects
- result is a recording, easily replayed
Why digital differencing?

- Changes problem from “can you hear a difference?” to “can you hear *anything*?"

- Result is a recording, anyone can listen and draw his/her own conclusions from it

- Listeners are asked to use their ears, not distrust them
Complications

● An audible Difference track doesn’t mean the differences are audible while still part of the full audio signals. It’s a necessary but not sufficient requirement.

● Nearly anything not identical will leave an audible Difference track. And a lot of uninteresting effects can be different.

● There is always noise in an analog stage -- noise is always different.

Sound left in Difference track might be real. Silence almost certainly is real.
Equipment setup

-- needs as little as a computer and a soundcard. And software.
Audio DiffMakers’ Main Form in “Play-only” mode

“.dyf” file = a related .wav file collection
Audio DiffMakers’ Main Form in “All Functions” mode
Recorder Form

Audio DiffMaker - Recording REFERENCE track

**RECORD input**
- STOP recording
- Record input Mixer

- Use software record monitoring from [not available, being used for Source]

**SOURCE output during record, from SB Audigy 2 [FFC0]**
- AllBluesSource.wav
- Source Out Mixer

**Record Time**: 00:01:322

**PLAYBACK saved recording**
- Play Back
- Monitor/Playback Mixer

- Return to Main and use saved recording as REFERENCE
- Cancel and return to Main form

Recording device is SB Audigy 2 [FFC0] at 16 bits resolution, 48000 Samples/sec, two channels
“Acquire equalization” Form

--- uses log sweeps to get impulse responses for compensating linear responses (optional)
An easier check for response differences -- the Response Analyzer
“Uninteresting” differences

- **Time delay** offsets (between Reference and Compared)
- **Level** (volume) changes -- easy to fix
- Very small **sample rate** variations
- Linear **frequency response** changes -- maybe significant, but easily detected other ways and fixable
- Sound card system gaps: *more common than you think!*
  Check for **Deferred Procedure Call** (DPC) errors:
  
  www.thesycon.de/deu/latency_check.shtm
Time (or phase) mismatch error

- Frequency dependent (worse at HF)
- Phase error limits null depth of each component to:

$$10 \log (2 - 2 \cos \theta) \quad [dB]$$

A 55db null at 3kHz requires delay matched within 93 nsec!
Gain (level) mismatch error

Gain error of E [dB] limits null depth to:

$$R = 20 \log \left( \left| 1 - 10^{E/20} \right| \right) \ [dB]$$

Example:
Need to be within 0.03 dB to get a 50 dB null!
Speed (sample rate, clock drift) errors
-sound card errors included

With a 0.1 ppm rate mismatch, delay would be off by 1usec within 10seconds:
Null depth of only 35 dB at 3kHz!

- Sample rate compensation can be used
- But doesn’t work well combined with equalization
- The best fix is to lock sample clocks
**Difference extraction process**

- optimizes parameters for lowest correlated level in Difference track

- deep nulls can be difficult to get! --but can run “dummy tests” with ‘should-be-same’ signals to verify recordings are stable
Demonstrations of some Difference file results

- Series coupling capacitors -- polypropylene film vs. Z5U ceramic disk
- The green felt marker CD tweak!
- Power amplifiers
- 24/88 and 16/44 format
- MP3 compression
- and a listener challenge
Audio DiffMaker

(free program download)

from

www.libinst.com