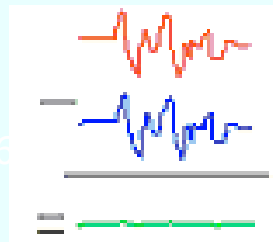


Detecting Changes in Audio Signals by Digital Differencing

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Audio DiffMaker



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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?

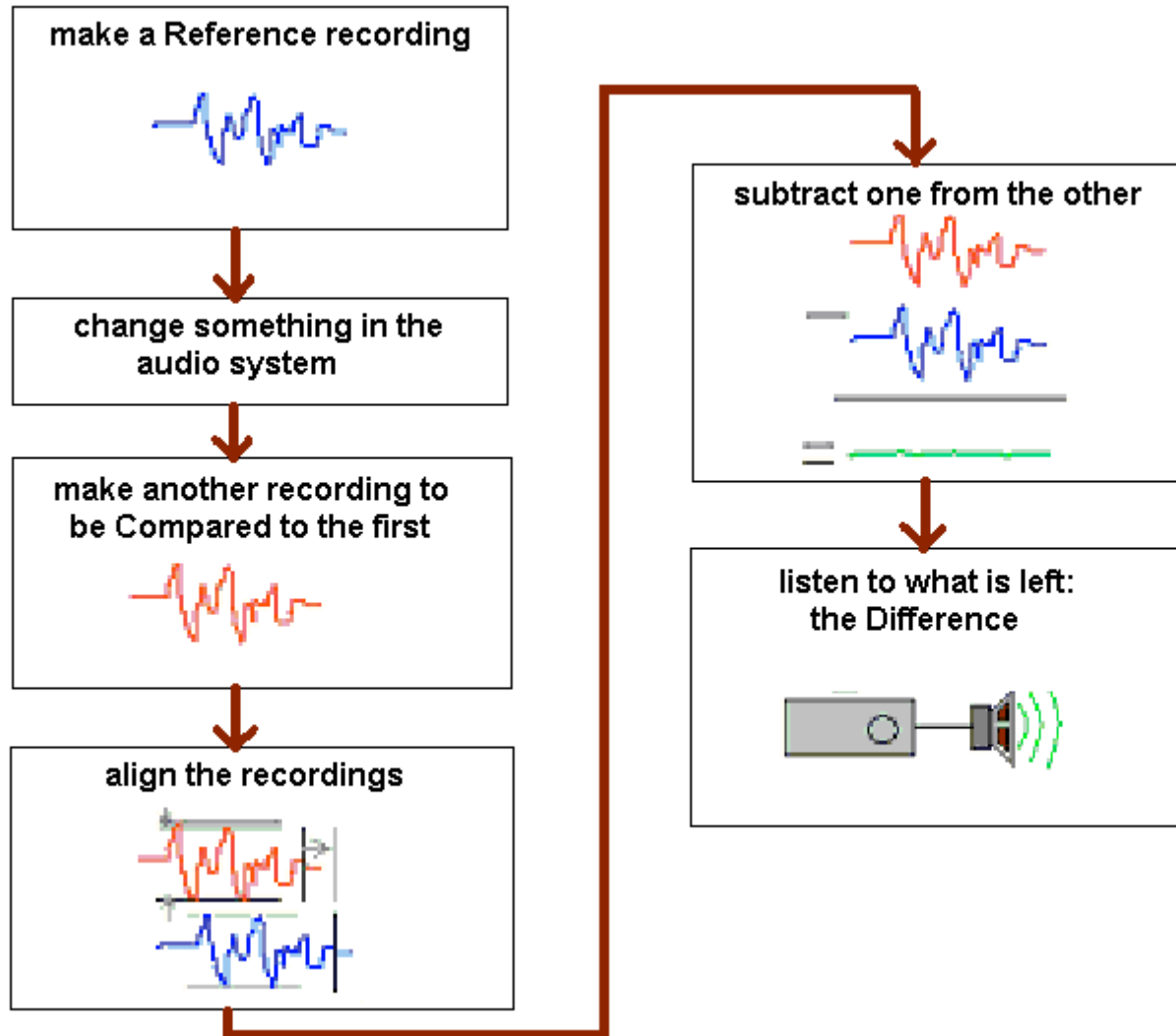
Subjectivist

"I know what I hear", "you should trust your ears"

Objectivist

If not demonstrated in blind tests = "placebo effect"

Isolate differences by subtracting



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

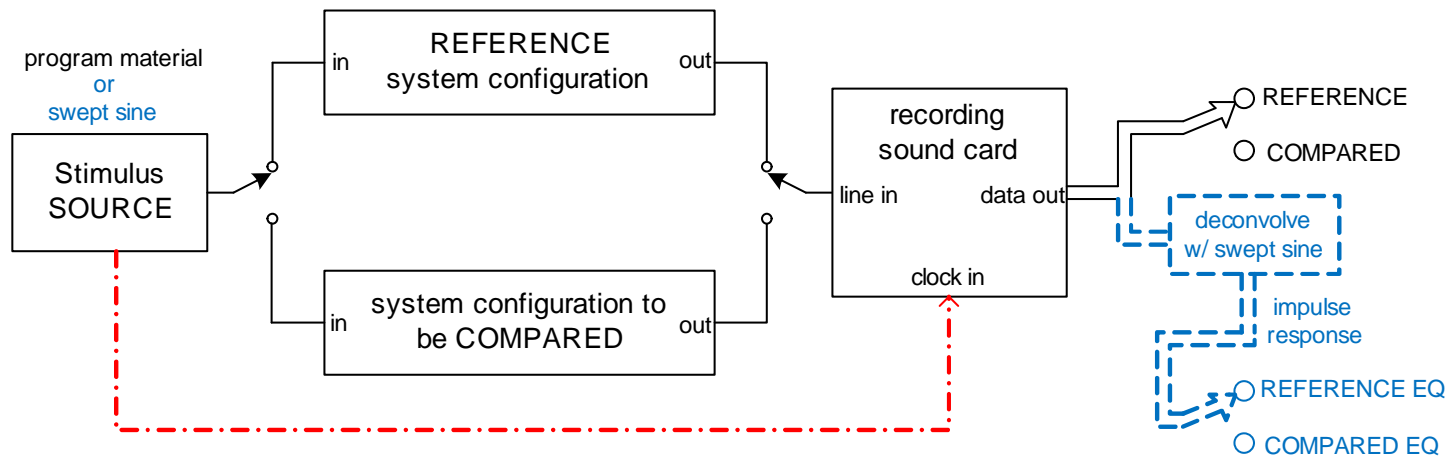


Complications

- 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



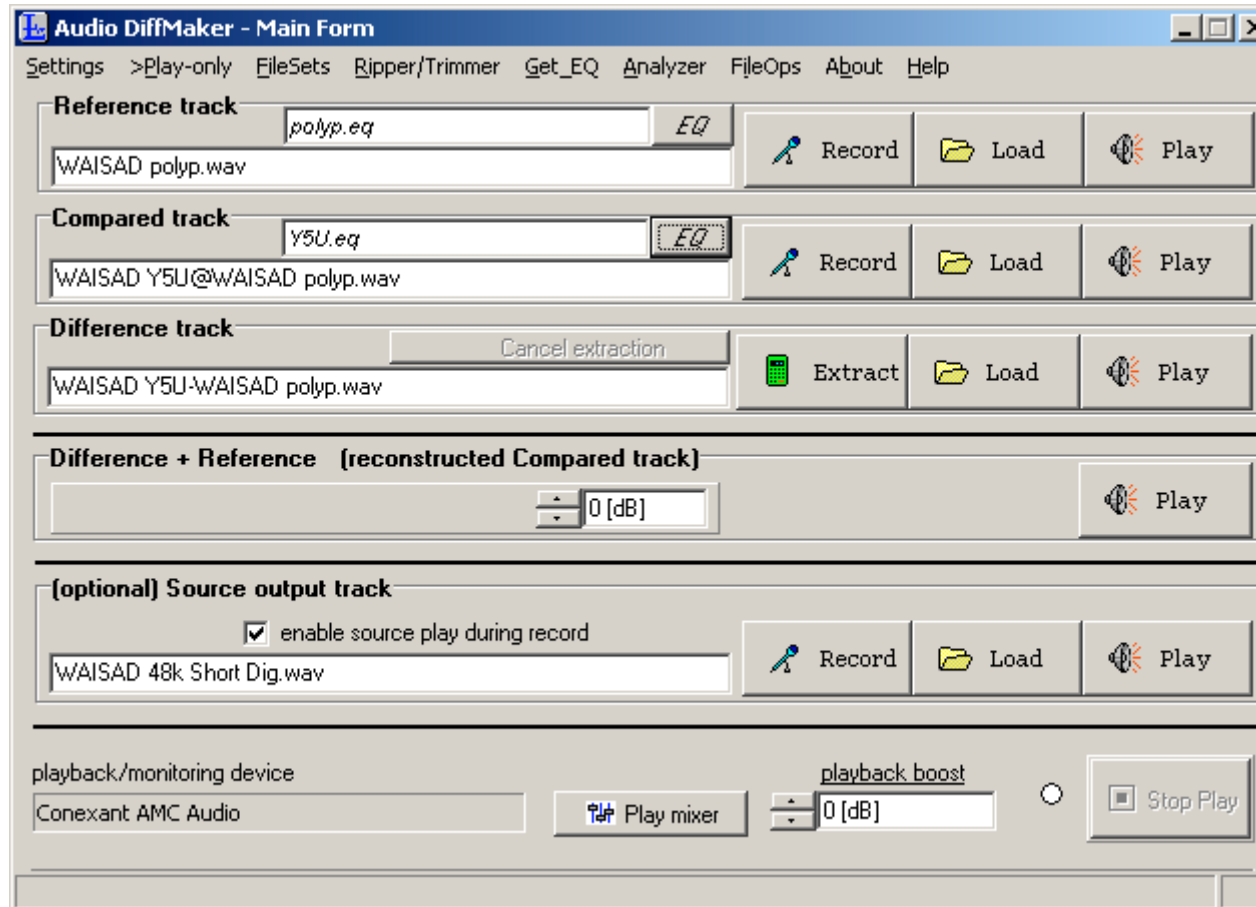
-- needs as little as a computer and a soundcard.
And software.

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


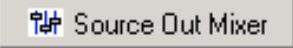
Settings Help



RECORD input

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

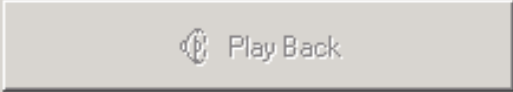

SOURCE output during record, from SB Audigy 2 [FFC0]

AllBluesSource.wav  

L 
R 

Record Time 00:01:322

PLAYBACK saved recording

Return to Main and use saved recording as REFERENCE

Cancel and return to Main form

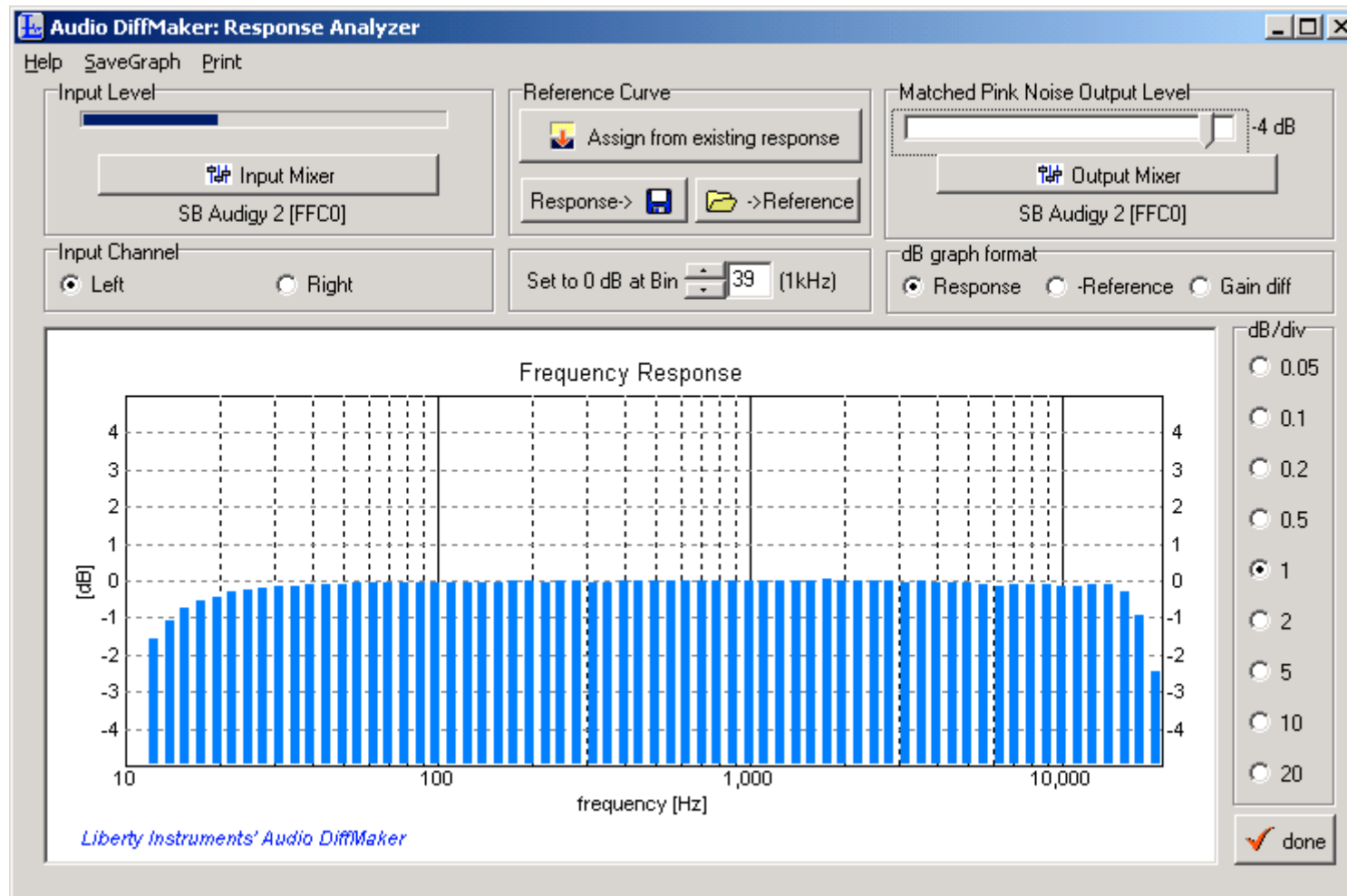
Recording device is SB Audigy 2 [FFC0] at 16 bits resolution, 48000 Samples/sec, two channels

“Acquire equalization” Form

The screenshot shows a software window titled "Acquire equalization curve" with a menu bar containing "Settings" and "ScopeView". The main area displays recording parameters: "recording sample rate is 96ksps", "recording resolution is 24bits", and "2 recording channels enabled". A blue italicized instruction reads "click Start to begin measurement". Below this is a "Start" button with a play icon. To the left are two level meters for "L" and "R" channels. To the right are "Record input Mixer" and "Output Mixer" buttons. A checked checkbox labeled "play sweep from soundcard" is present. A section titled "to make a WAV file of this sweep signal" contains a "Resolution" section with radio buttons for "16 bits" (selected) and "24 bits", a "sample rate of intended play device" dropdown menu set to "44.1 kbps", a "time length" spinner set to "100 [sec]", and a "make WAV file" button. At the bottom right is a "return" button with a checkmark icon.

-- uses log sweeps to get impulse responses for compensating linear responses (optional)

An easier check for response differences -- the Response Analyzer



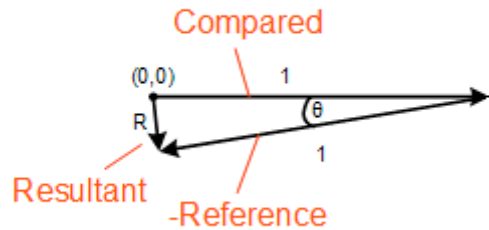
“Uninteresting” differences

- **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

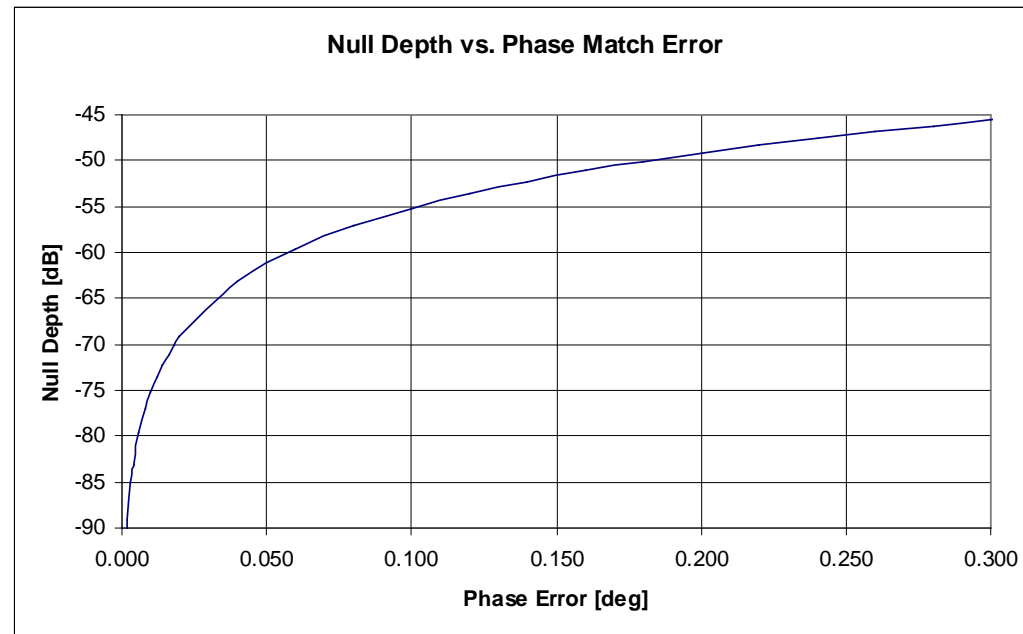
Time (or phase) mismatch error

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



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

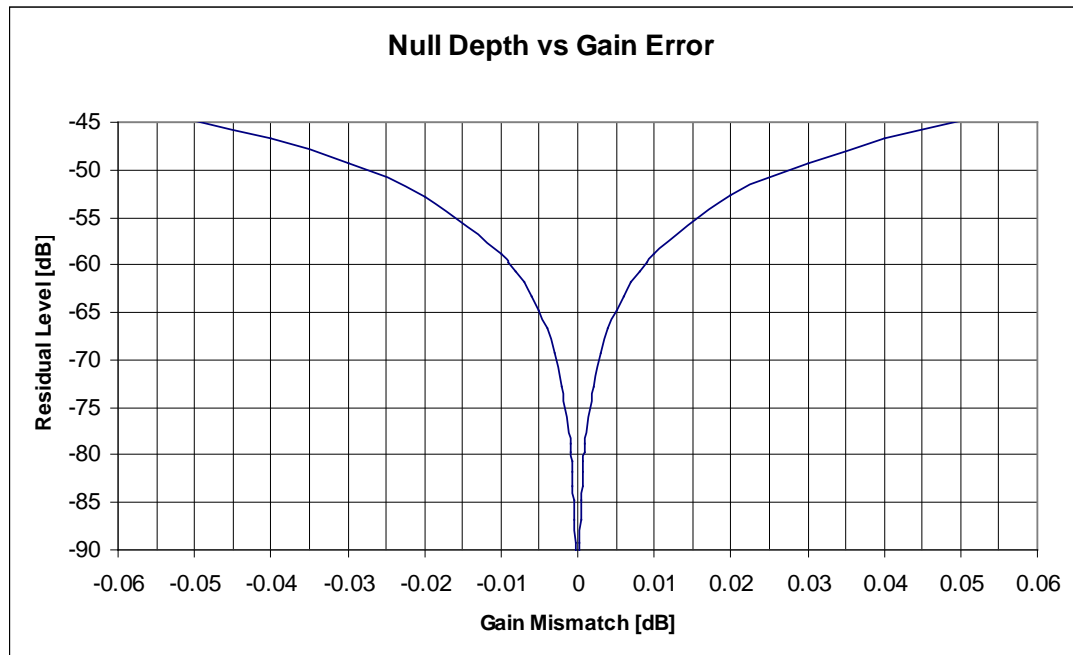
A 55db null at 3kHz requires delay matched within 93 **nsec**!



Gain (level) mismatch error

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

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

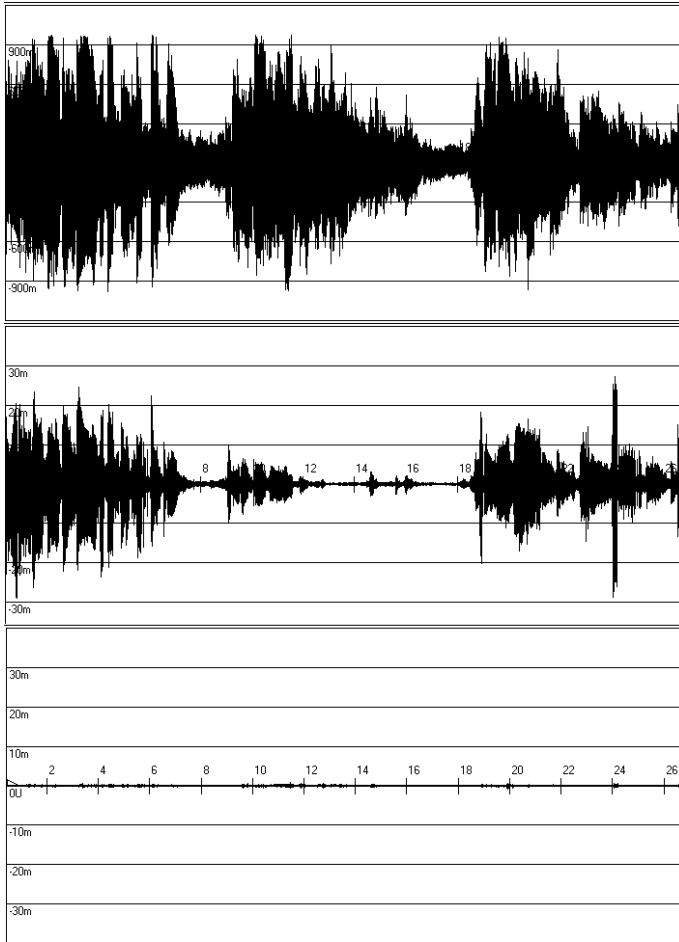


Example:

Need to be within
0.03 dB to get a
50 dB null!

Speed (sample rate, clock drift) errors

-sound card errors included

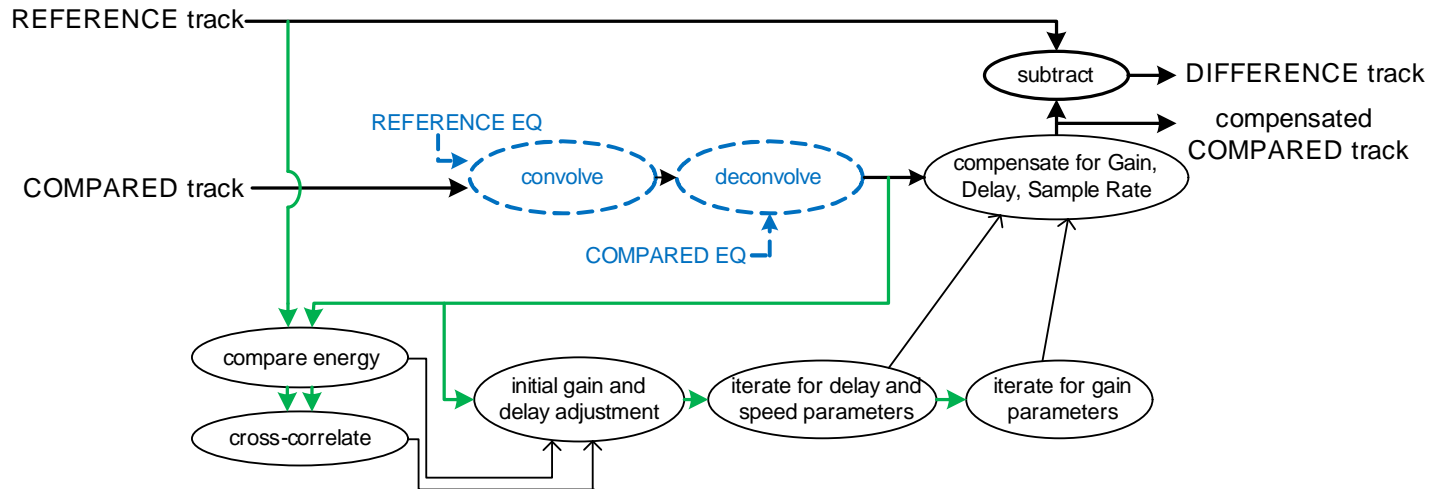


With a **0.1 ppm** rate mismatch, delay would be off by 1usec within 10seconds:

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