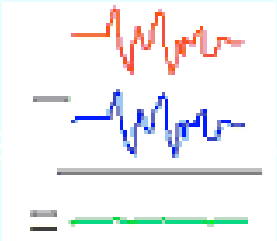
Detecting Changes in Audio Signals by Digital Differencing

Bill Waslo

Liberty Instruments Inc.

Audio DiffMaker



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

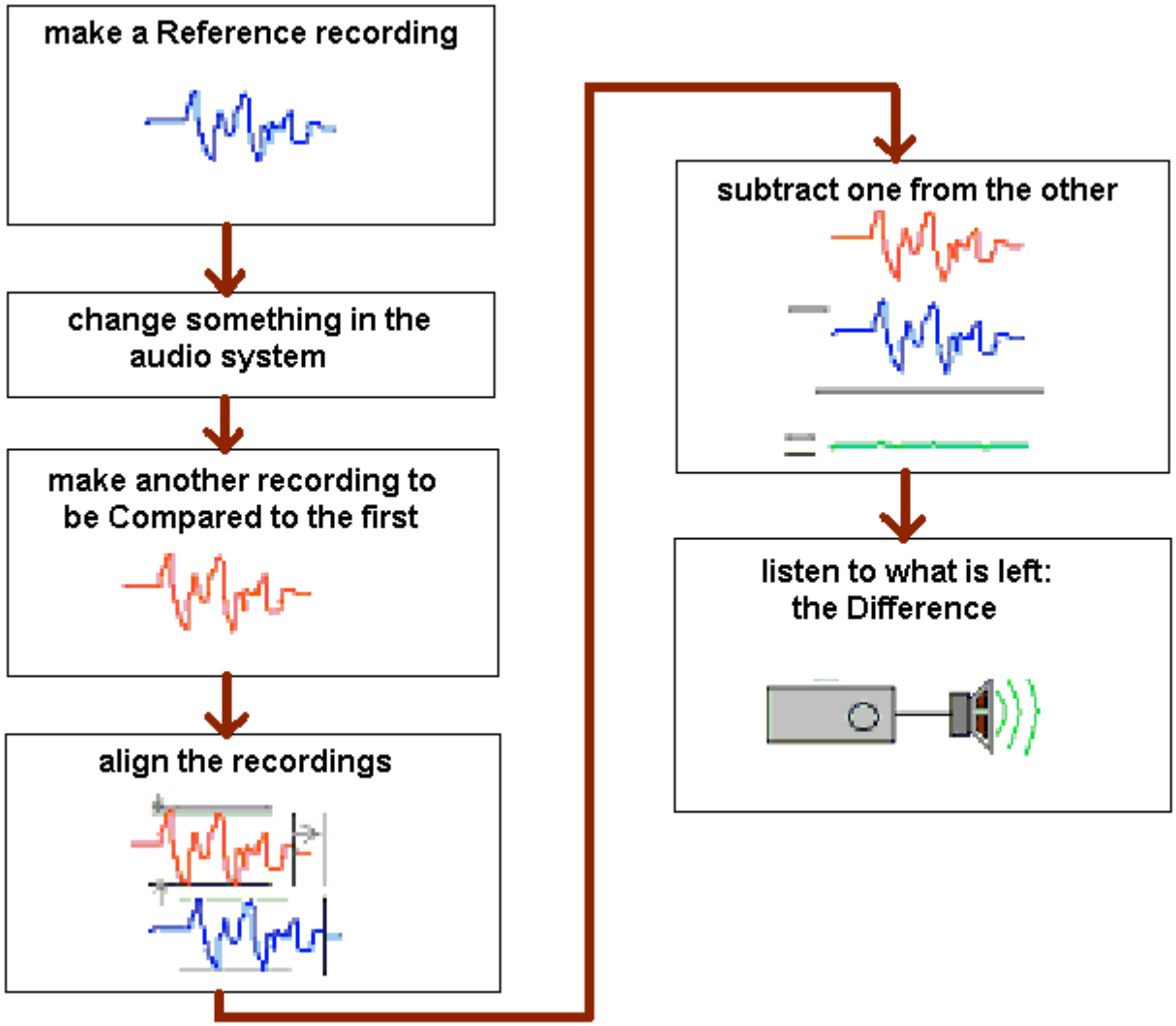
Are listeners actually hearing differences?

How can you be sure what is heard?

Is there always anything *to* hear?

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

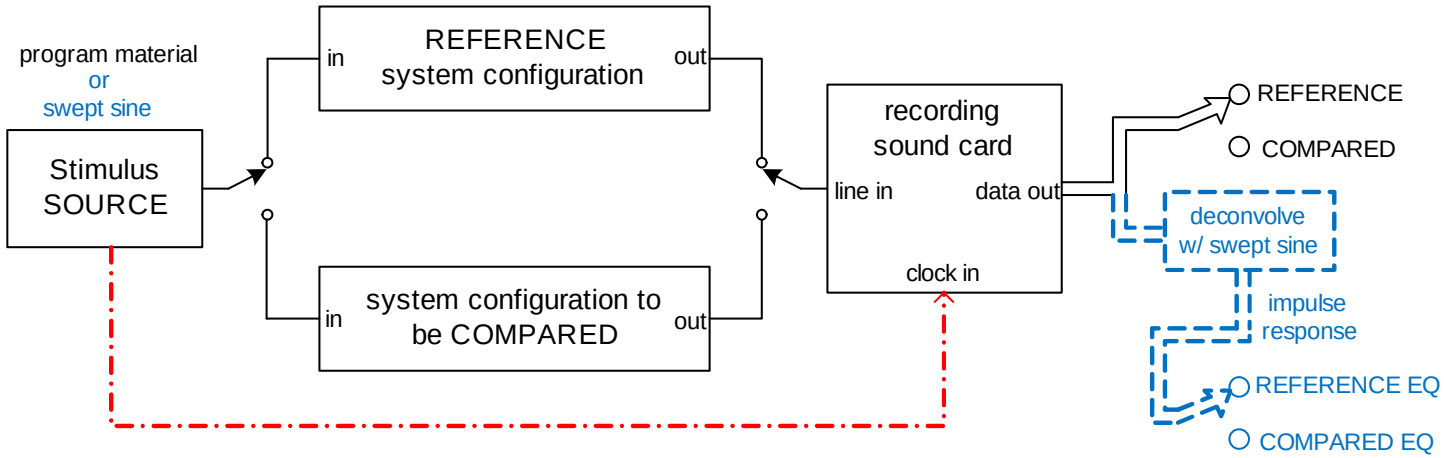
- An audible Difference track doesn't mean the differences are audible while still part of the full audio signals. It's a *necessary* but not *sufficient* requirement.

- 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.

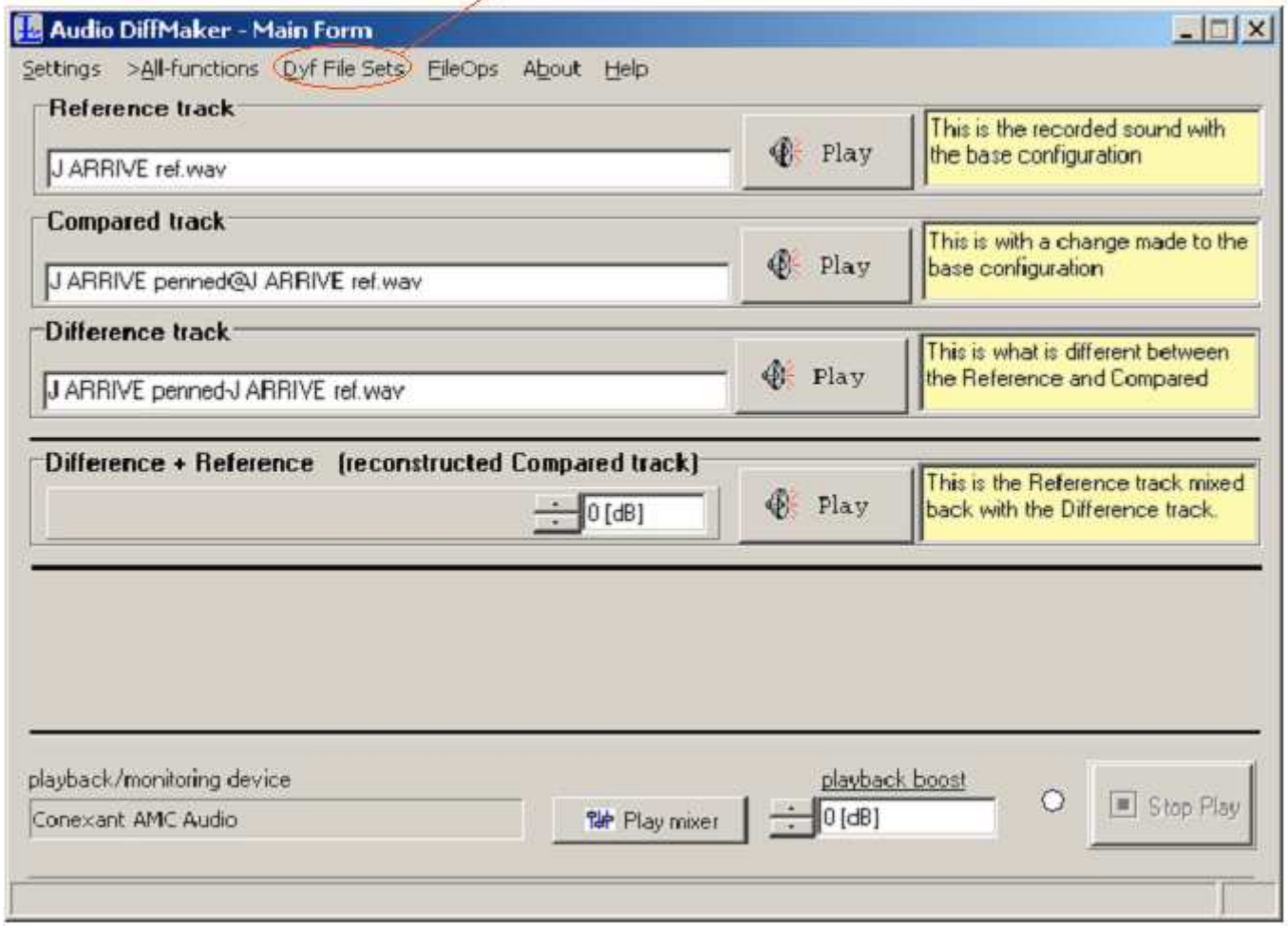
Equipment setup



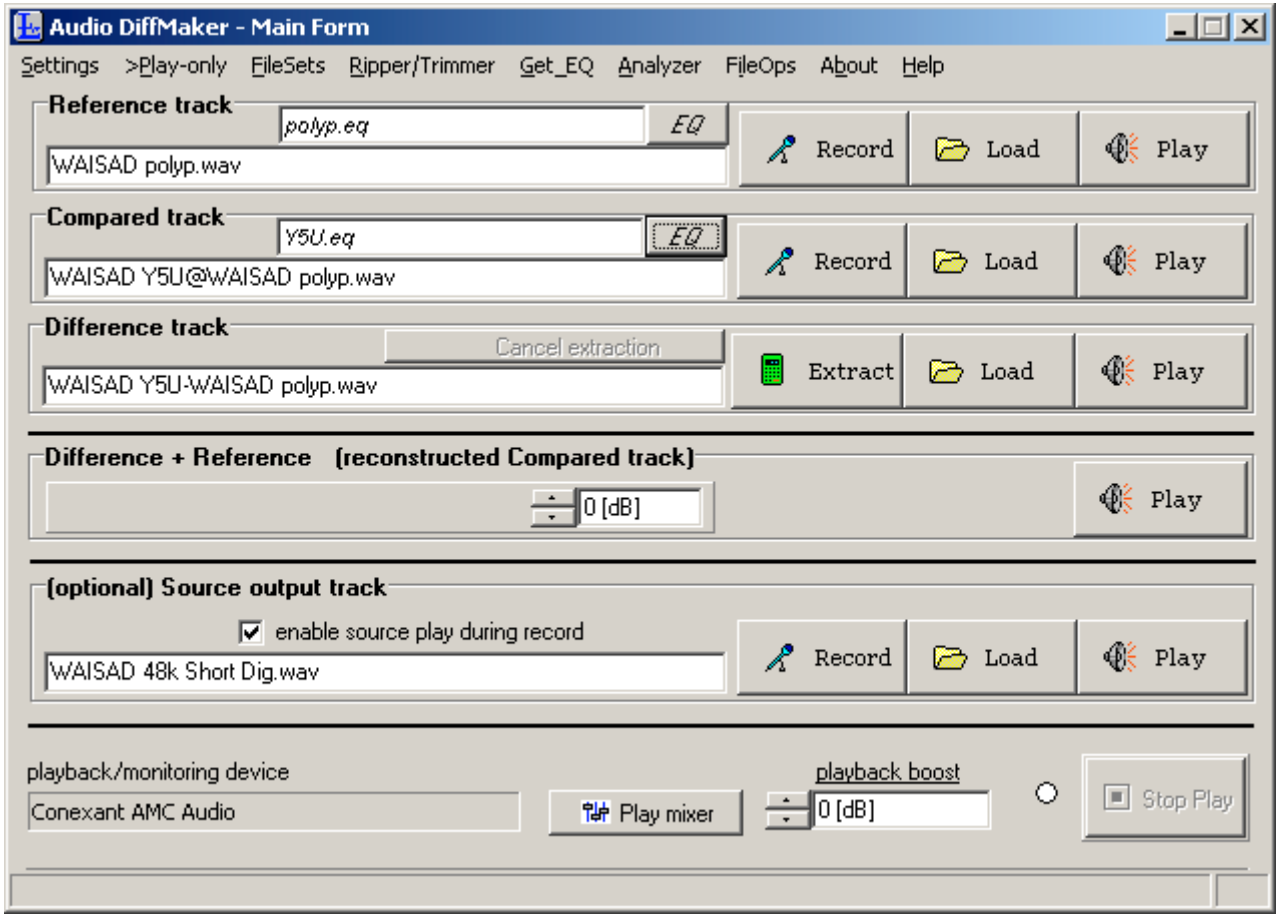
-- needs as little as a computer and a soundcard.
And software.

Audio DiffMakers' Main Form in "Play-only" mode

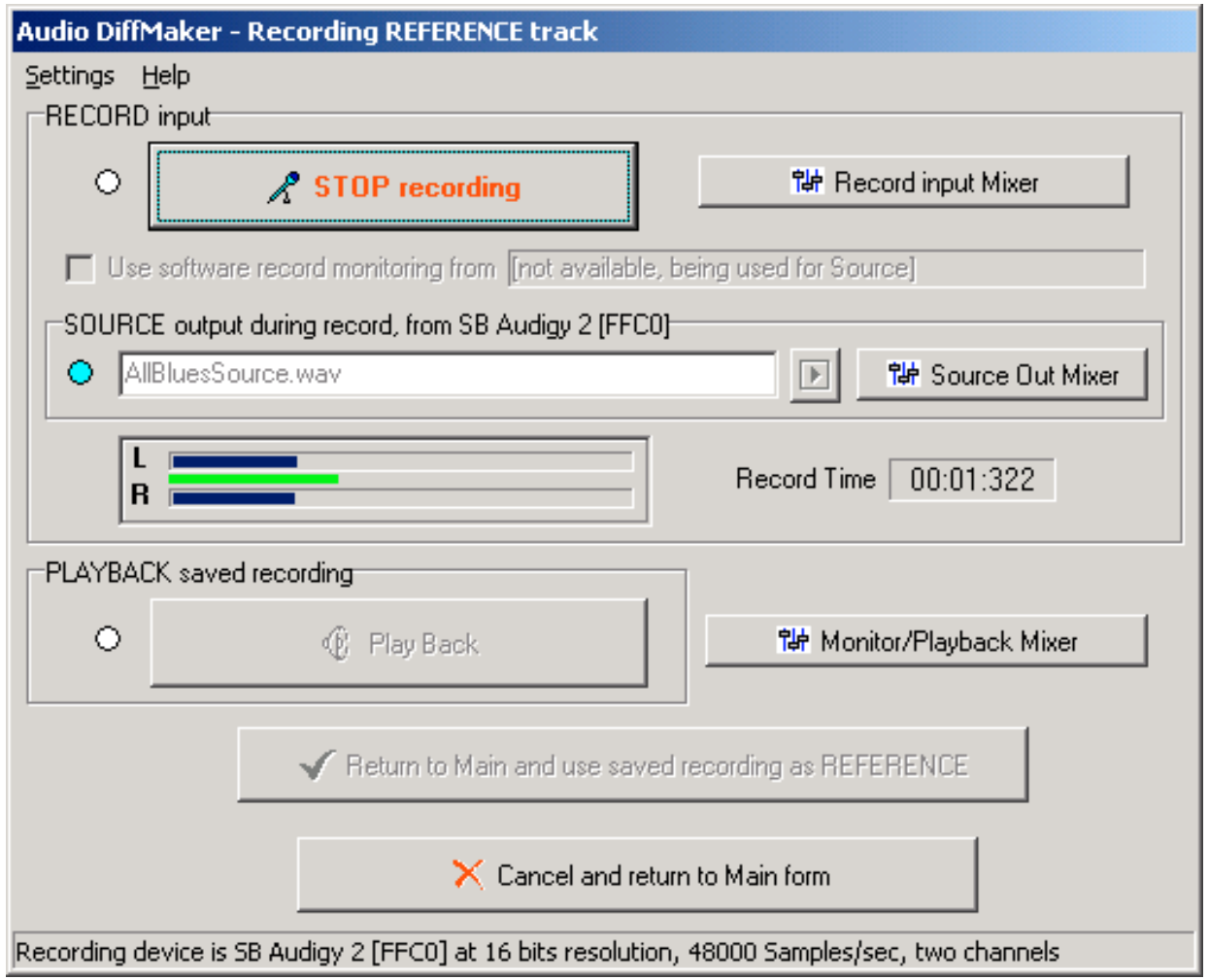
".dyf" file = a related .wav file collection



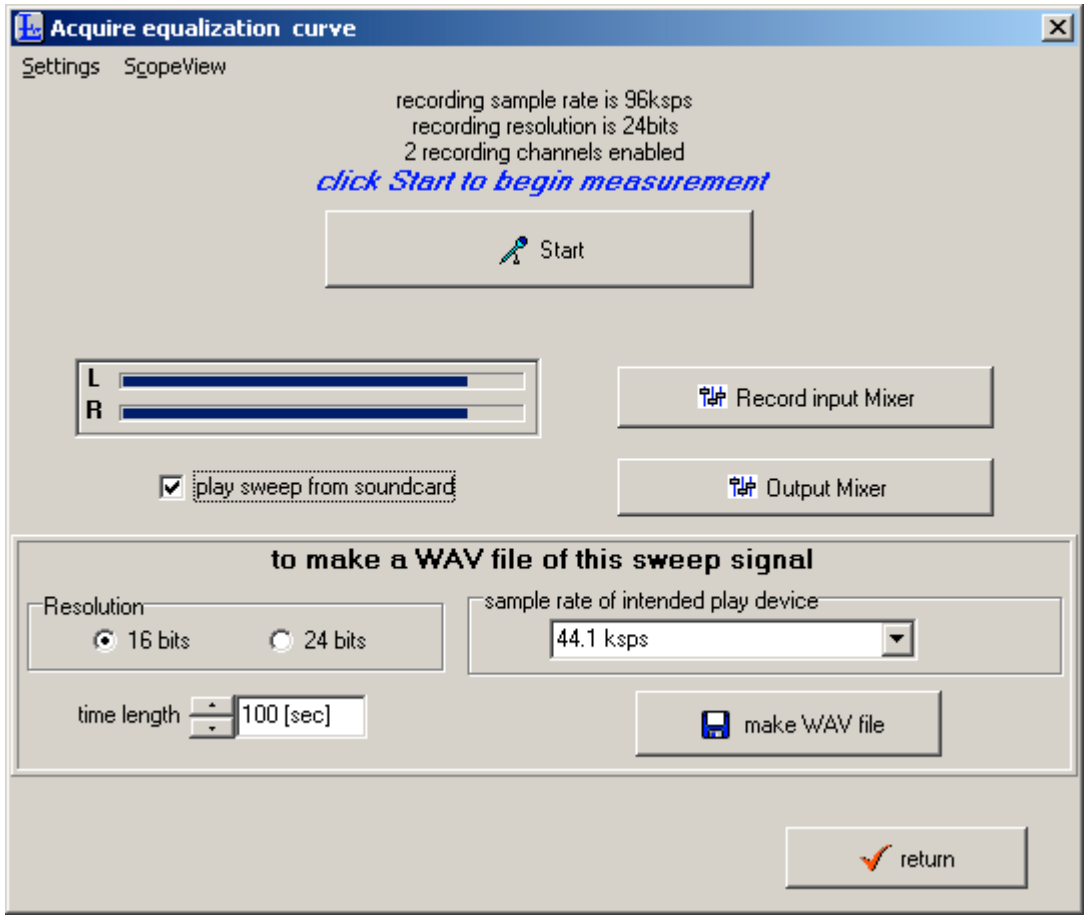
Audio DiffMakers' Main Form in "All Functions" mode



Recorder Form

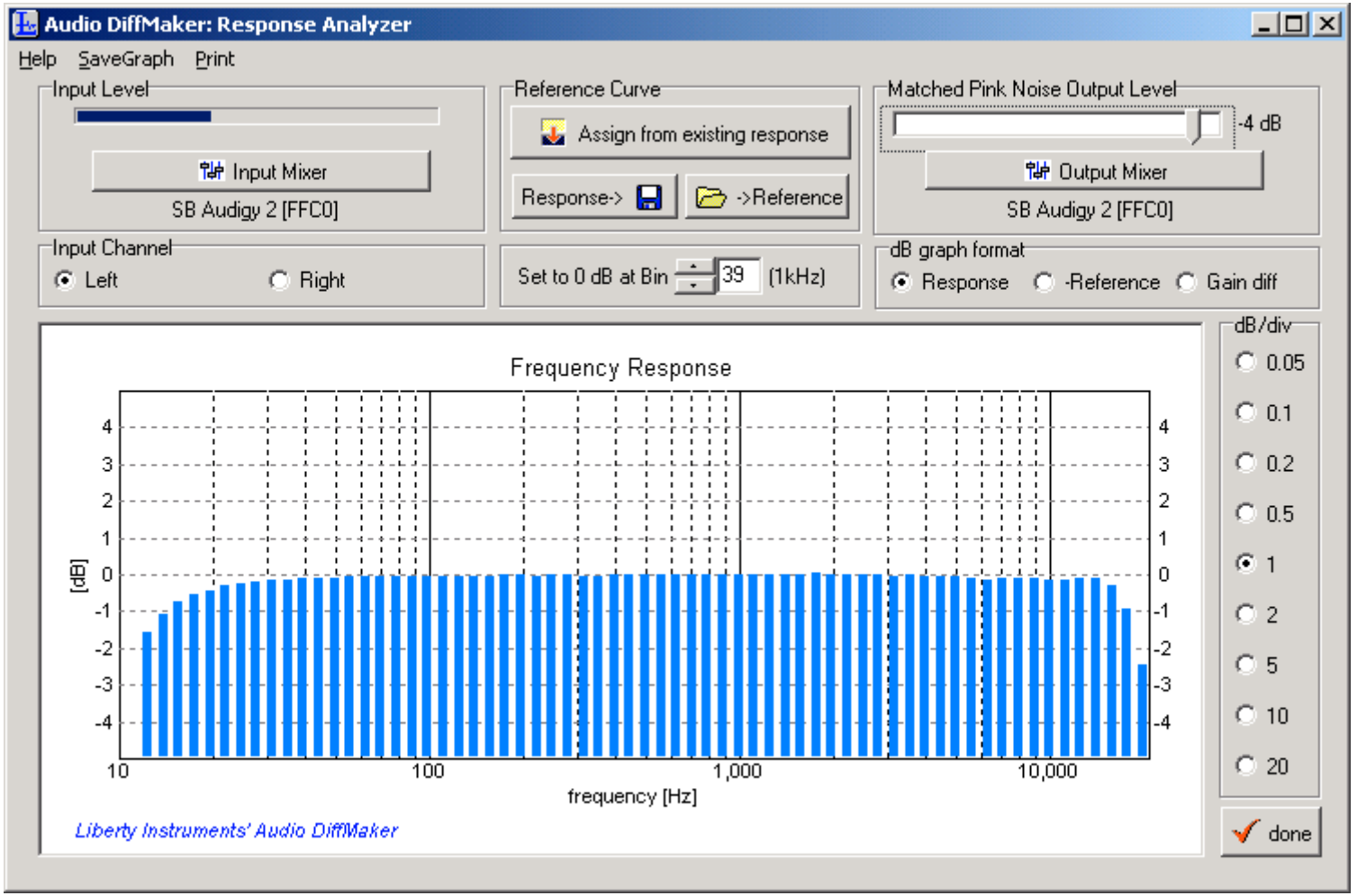


“Acquire equalization” Form



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

An easier check for response differences -- the Response Analyzer

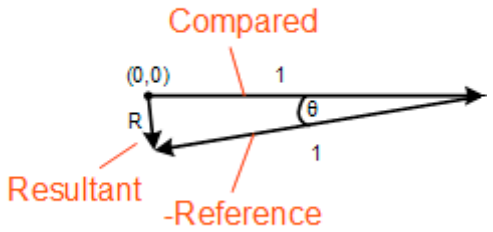


“Uninteresting” differences

- **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

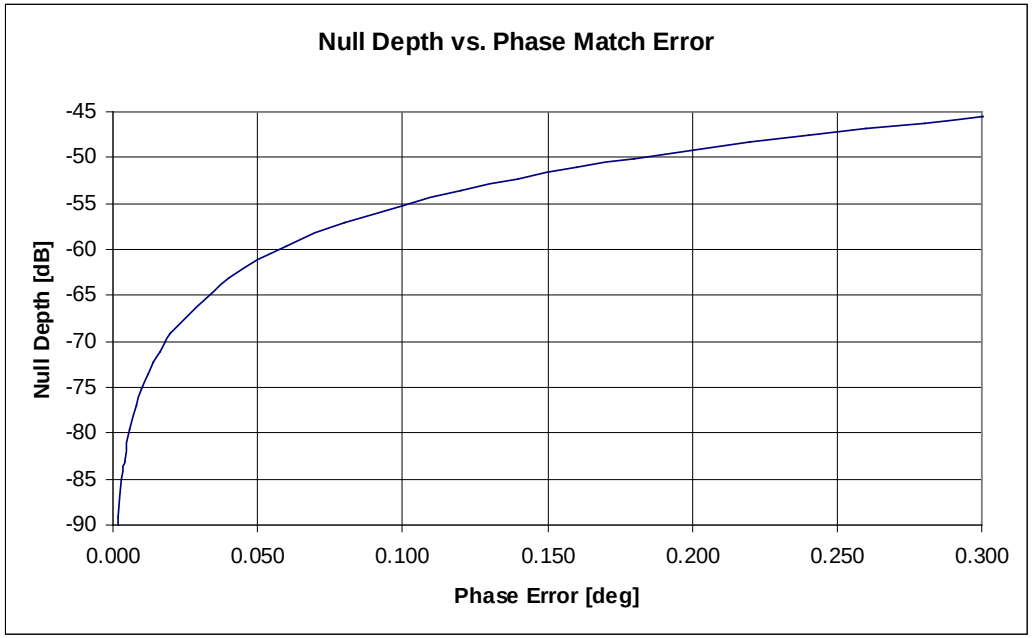
Time (or phase) mismatch error



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

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

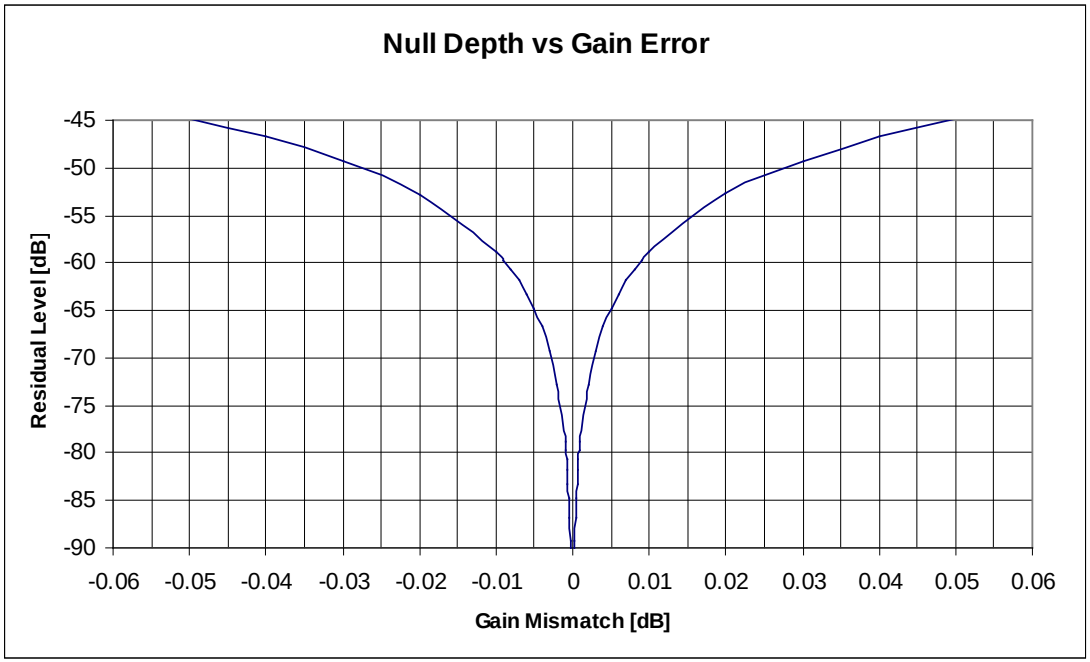
A 55db null at 3kHz requires delay matched within 93 **nsec**!



Gain (level) mismatch error

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

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

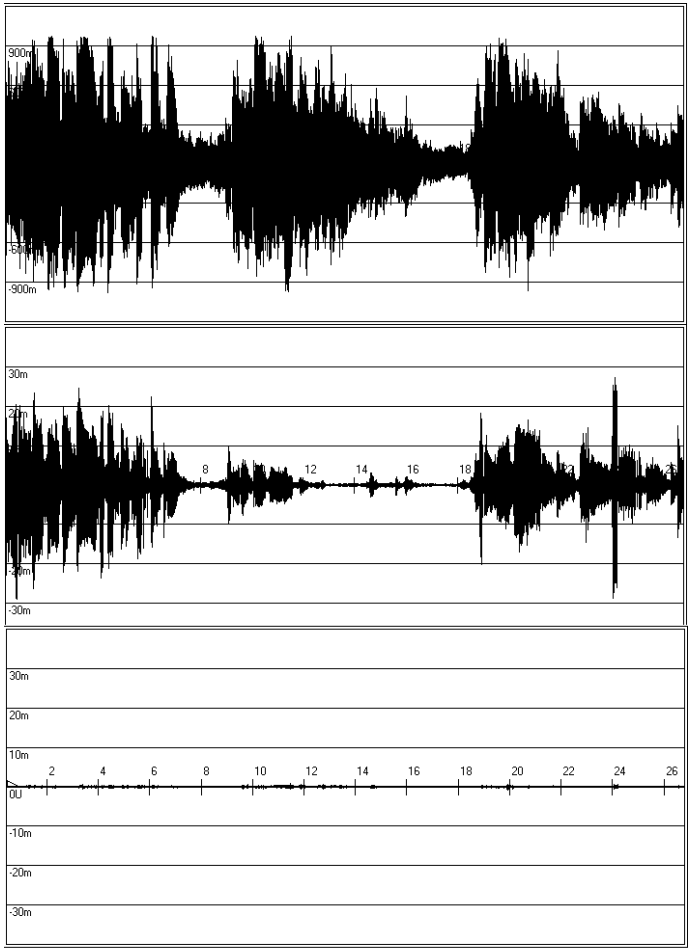


Example:

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

Speed (sample rate, clock drift) errors

-sound card errors included

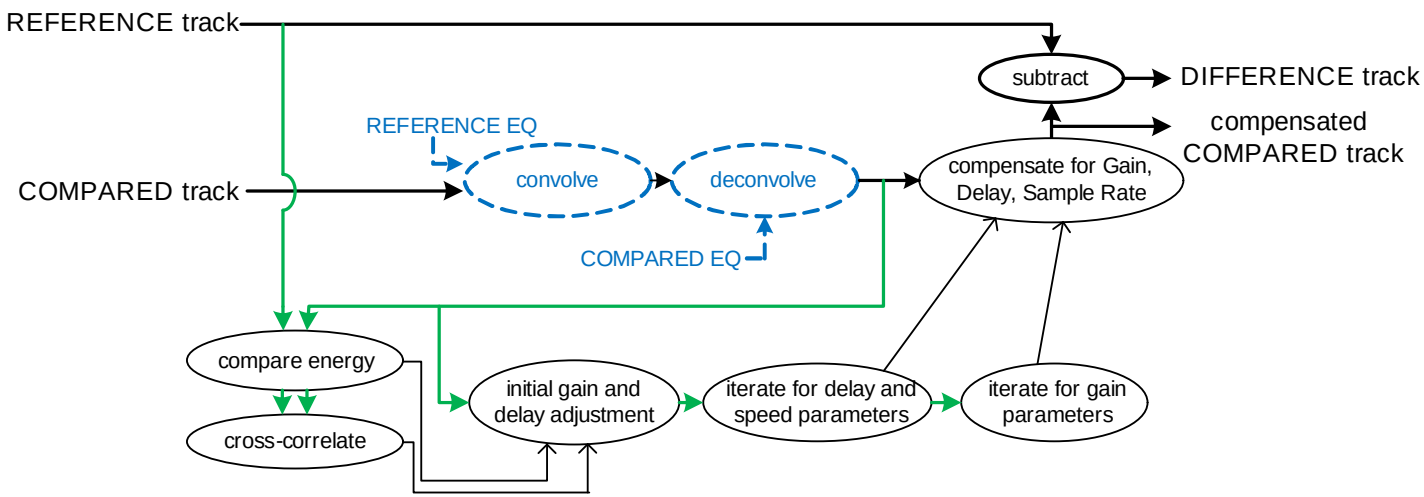


With a **0.1 ppm** rate mismatch, delay would be off by 1usec within 10seconds:

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