**Project Description**

E.R. Hanson 🡪 loudspeakers should be better than they are. Nearly always run open-loop and without compensation. Open-loop compensation = cheap and (fairly) easy way to get better response out of the same hardware. Closed-loop compensation splits into: a) real-time feedback i.e. collecting signals that represent various loudspeaker parameters and controlling these to improve distortion, b) disturbance and uncertainty observer estimation i.e. predicting what noise will get added into signal chain and controlling against this, and predicting how the loudspeaker’s properties will change over time and controlling against this = less cheap and less cheerful but more powerful way to achieve close to linear response.

Basically, why not use both?

Impact on society: audiophiles can spend less money to get better sound OR companies could get more profit from existing systems, control mechanisms can apply to any moving piston-type actuator… provides a reference control setup for potentially countless devices.

**Project Specification**

[as in other document]

**Background Theory and Methodology**

**Loudspeaker Physics + Systems + Equivalent Circuit**

We want to try and model everything using equivalent circuit model since we can then at least design a box so that we have something to work with.

Electrical part: forms a low-pass filter – filtering action occurs at sufficiently high frequencies such that we don’t care. Equivalent circuit models: UNCHANGED

Mechanical part forms band-pass filter: below resonance, cone is moving slowly but excursing far to try and push enough air to get the low frequency sounds out. Bigger current at low frequency due to more force needed. Above resonance, not much air volume needs to be moved and the cone moves fast and little – cone mass limits action since more acceleration and therefore more force needed at progressively higher frequencies. Equivalent circuit models: [as in other doc]

Box: compresses the air around the driver, stiffening it up and increasing compliance. Also adds damping effects for some reason.

So now let’s create equivalent circuit model. But wait – driver data sheet doesn’t have these written explicitly 🡪 what are Thiele/Small parameters.

[Logbook equations to derive everything]

How should we create a box? [MATLAB script – basically add compliance and creates new T/S parameters based on how much you want to change loudspeaker response, just try not to change the original response too much]

New equivalent circuit model.

We could add more stuff for accuracy’s sake, but this isn’t necessary. This part of the project is meant to exist just to build something tangible to work with.

**Building the box**

Describe trials and tribulations of gluing and screwing some MDF together.

**Open-loop compensator**

AKA equalisation. We’re not actually controlling anything, just extending the response of the existing stuff that’s already there.

Conventional EQ-ing [Linkwitz]: measure frequency response, find poles, introduce zeroes at those poles.

Linkwitz Transform [http://www.linkwitzlab.com/images/graphics/sb186-48.gif]: is better – reduces group delay, so the speed of response is now improved. Tradeoffs = more excursion and power needed to achieve extended response. Mitigating tradeoffs = excursion controller would deal with >Xmax, limit power intake and accept that full dB volume output may be compromised at lowest frequencies (although Bl and speaker compliance might mean that that power may be achieveable…) https://sound-au.com/linkwitz-transform.htm#compromise

**Results**

Simulation results. Show that LT works and that power / Xmax is obeyed. Show box CAD.

**Discussion**

Rip into progress thus far as in other document.