**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. Inductor is so small that uH discrepancies don’t really affect overall design – can even ignore it. 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 🡪 reference his paper.

[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.

It would be too time-consuming to design and build three independent enclosures for three different subwoofers. Also, the scope of the project is not to design a perfect enclosure – the scope of the project is to improve an existing system with electronics. Therefore, the ‘one size fits all’ enclosure was designed and built from the nominal specification values. This will not affect the electronic compensation stage, since the box’s equivalent circuit parameters are independent from those of the driver. Re-measurements of impedances and TSPs will take place once a subwoofer is seated in an enclosure – this gives a realistic impedance view of the actual system that will be controlled by the electronics, as opposed to theoretical views.

**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.