



Solo-206

The Solo 206 rear-loaded full-range horn speaker - concept

After building the Solo 103 I got the taste for full-range drivers. Seeing as the Fostex FE103 was rather limited in the bass output level I decided to take a different approach for bass loading. I wanted more efficiency in the bass and lower midrange so a logical way to go was the rear-loaded-horn. Also I wanted even higher overall efficiency so that meant a larger full range driver. Seeing as I have only built a few horn-speakers before I thought I would play it safe and modify an existing and proven design instead of trying to create a completely new one. I got my inspiration from an old Fostex design, the BK201.



The driver

The [Fostex FE206E](#). A not very expensive 200mm (8 in) twin cone type full range driver using a non-coated 'ES cone' made of paper reinforced with banana plant's fibre. They appear well built and attention has been paid to every last little detail, they even come equipped with datasheets, self-adhesive mounting foam strips and a nice set of black coated screws and washers. The driver uses a simple stamped steel chassis holding a lightweight short voice coil moving assembly and an extremely large magnet. The only bad thing I could find with this driver is that the stamped steel chassis seems a bit flimsy considering the size of the driver. I made two mechanical alterations to the construction:

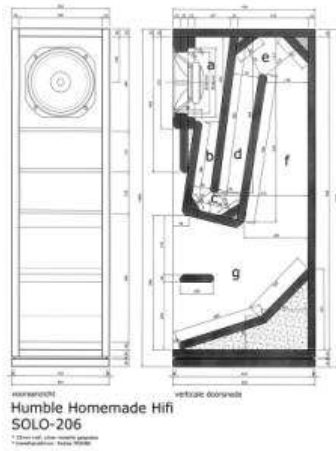
1. Cover the rear of the stamped steel chassis with strips of 4mm thick self-adhesive bitumen. This cuts down the "ringing" of the metal chassis.
2. Cover the magnet with a layer of felt. Because the magnet is so big it forms of course a large reflective surface, covering it with felt will reduce the amount of upper-mid and high frequency energy reflected in the cabinet and therefore entering the horn contour to be magnified.



The original and modified.

The moving mass is 15,35 grams, which isn't much for an 8" driver. Combined with a strong magnetic force BL of 11,8Tm this results in an acceleration factor of 767! Frequency response is up to just over 20kHz, which is very good for a single driver speaker of this size. Sensitivity is rated at 96dB at 1W/1m. Continuous power rating is 30 watts; together with the high efficiency this unit should be able to play very loud. Resonance frequency f_s is 39Hz and X_{max} is 1,5mm.

Cabinet construction and internal damping



On the left: Pre-cut cabinet panels for two enclosures, the round red thing on the left is a CD to give an idea of the size.

On the right: The cabinet drawing, the letters a to g correspond with the comments about the amount and positioning of the damping material. A larger resolution drawing is available on request.

Compared to the Fostex BK201 cabinet I made mine taller so that the horn length increased and there was more space for a larger horn mouth, both alterations aimed at lowering the low frequency cut-off point and making the cabinet look slimmer and therefore more attractive. All panels are made of 22mm mdf. All outside edges are routed with a 12mm rounded edge. This is only done for looks, an 8-inch full-range driver beams at higher frequencies so there is not much trouble with reflections from the baffle edges. The internal folding sections are routed with a 12mm rounded edge to contribute to a smooth as possible path through the horn. To make the cabinet as heavy as possible and cut down unwanted panel resonances I filled all the hollow compartments behind the horn foldings (also the large bottom one) with dry silver-sand. An extra brace in the horn mouth are also cuts down the unwanted "flapping" of the side panels, airflow is not obstructed due to the rounding off of the edges of the brace.



On the left: The rough cabinet; you can also see the carpet in the driver compartment.

On the right: The damping material around the driver in place. Note the thickness of the baffle that is contoured to the inside.

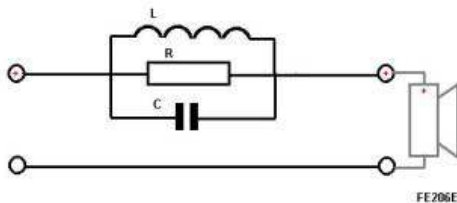
The first half of the horn contour (up to the top back section - sections a, b, c, d and e) is lined with carpet on one side of the horn

contour panels. If anyone wants to know, I used the same carpet as in the Solo-103, there is no Zen idea behind this, its just because recently we had our stairs carpeted and I kept all the cut-offs and leftovers especially for use in loudspeaker enclosures. Other damping material is a piece of Monacor MDM-3 (that consist of 2/3 sheep's wool and 1/3 polyester fibre) of about 30x30cm placed directly behind the driver in section a. Furthermore a piece of Pritex foam of about 10x60cm is lined in a U-shape against the cabinet walls above and to the left and right of the driver, also in section a. The rear of the horn from the top to where the mouth begins (section f) is filled with BAF; this contributes to a clearer mid-range. In this area of the horn the side and rear walls are also covered with bitumen. The final section g is free from any type of damping material.

To tilt the cabinet backwards slightly so that the driver can be "aimed" at ear-height there is a plank under the front, the two "spikes" make it height adjustable. The cabinet has three little metal feet to give optimum contact to the floor. On the rear of the cabinet I used a pair of standard binding posts.

The crossover network

Initial idea: What crossover? Where? The tonal balancing was first done by adding and removing damping material, trying different types and combinations of damping material and playing around with the place of the damping material. So the driver was connected directly to the binding-posts with no crossover component in between. But after extensive listening to all types of music (also bad-recordings and pop-music) I decided to add a correction network after all – without a correction network the midrange could get a little "hollow" some times. All that is used here is a simple notch filter to lower the midrange output level to match the bass and treble better. Even though the drivers used are rather cheap I would advise to use the best filter components you can get (there are only three per speaker so it won't cost that much). The inductor must have an air-core for no saturation and low distortion. The lower Rdc the better, it improves bass response and mid-range attack. It is amazing how sensitive the capacitor is, using a standard Audyn Cap MKP or similar is a waste! A good price/quality ratio is achieved with a LeClanché or Mundorf M-Cap capacitor. When a high-end Audyn Cap Plus or Mundorf Supreme Cap is used the amount of extra clarity and detailing is surprising. I used a metal oxide resistor, here again personal taste will determine what is needed, standard cemented resistors are out of the question.



Filter components:

L = 1,0 mH air-core inductor min. 2,00 mm wire, R = 0,17 ohms

C = 2,42uF MKP polypropylene foil capacitor (2,2uF + 0,22uF) – LeClanché, Audyn Cap Plus or Mundorf Supreme Cap

R = 10 ohms, 10 watts metalfilm resistor

Listening impressions and remarks

Well it's a big step up in maximum sound pressure level and bass extension from the Solo-103. When coupled to my EL84 push-pull tube amp delivering 2x 8watts into an 8-ohm load, combined with their 96dB efficiency without crossover or 93dB efficiency with crossover, they can produce extremely high levels of sound. Bass is full bodied down to about 50Hz; below that there is nothing due to the relatively "compact" size of the horn. With the correction network in place bass seems more solid. Real sub-bass is missing but you only really miss this when compared to speakers that do extend down an octave lower. Care should be taken with speaker positioning in the room, if placed too close to a side wall they can get a bit muddy in the lower mid-range, I would advise about 60cm as a minimum from any side wall, preferably more. Funny thing is that placing them close to a rear wall doesn't mess them up.

They are slightly directional (a smaller sweet spot than average) but the sound stage still has depth and width. Like with the Solo-103 everything can be pinpointed in the virtual soundscape, although the Solo-103 does the "disappearing act" better. The mid-range has that nice fast and open character to it, being neutral at the same time when the correction network is in place. Without the correction network they can sound a little midrange favoured compared to some speakers, but the attack gained by leaving out a crossover can be a reason to leave it out. Coherence is another word that comes to mind. Also like the Solo-103 they do have a slight preference for intimate jazz trio's (try "Goodbye Pork-Pie Hat" on the Charles Mingus classic "Ah Um"), a Beethoven string quartet or solo vocals but the difference is when it gets heavy (large orchestral works or complex jazz-rock) everything still stays in place. Okay, some clarity is lost at extreme levels, here the shortcomings of a single cone trying to produce bass and treble at the same time show but you have to drive them really hard for this to happen. All in all highly recommended and not only for Single Ended Triode lovers!

Update January 2005

After working on speakers like The Monitor, Soup or Progress it was time to get back to basics, a bit "less-is-more" type of thing. Recently I was reunited with my Solo-206 speakers and had the urge to tweak them further. I wanted to go as pure as possible so I ditched the crossover network completely – no more concern about which ridiculously expensive high-end capacitor should I use! This gave an immediate gain in dynamics, speed and bite and the soundstage grew. But also the upper midrange glare came back. To balance the spectrum I removed ALL of the Monacor MDM-3 damping material from directly behind the driver in section A and also from the rear of the horn (section f). So the horn now only contains a bit of Pritex at the beginning and the carpet tiles in sections a, b, c, d and e. Bass is slightly less tight but the overall improvement is speed is very large. Removing the damping

material raises the upper bass / lower midrange region output level so it matches better with the upper frequency range.

The second tweak was to short the chassis of the driver to the minus pole of the connector. This is easily done by soldering a short piece of wire from the minus pole to the centre connection screw that holds the solder tab in place (see photo). This gave improved midrange clarity with a smoother treble and more punch in the bass – amazing for a 5-minute tweak that costs absolutely nothing!

I now hear things I had never heard in recordings before and all this from a simple cheap full-range driver! This speaker really lets you hear the acoustics of the recording studio and for example you can visualise how close to the piano and where the recording microphones are placed. I must admit it still doesn't like large orchestra's playing forte and lean recordings sound rather lean but otherwise I am very happy at the moment. The speaker works best with tube-amps: in combination with my KT88 monoblocks cymbals are so realistic it frightens you, with solid state they are a little too rough edged. Listening to track 11 on Diana Krall's "Live in Paris" you can hear the concert hall air vibrate, all the small noises the audience make are very tangible contributing to the effect that you are really there!



Update February 2005

Only one "problem" still to deal with: the beaming at high frequencies. I wanted to experiment with dispersing the energy with some sort of reflector or phase plug so that the higher frequency energy is more evenly radiated about the listening room and less directed on-axis. I had a *bright* idea! Looking at the various shapes and sizes of light bulbs I decided to listen to what would happen if I placed some of these directly in front of the driver. Conclusion: the larger the bulb and/or the closer the light-bulb is placed in front of the driver the greater the effect of a sort of "overall" soundstage, very diffuse a bit like an omni radiating speaker – the strongest with a standard light-bulb placed with glass directly in the wizzer-cone. The smaller the bulb and/or the further away it is placed from the driver the more direct and dynamic the speaker sounds – the smallest difference was with a small fitting candle-light bulb placed just before of the driver. A good compromise is the flat-ish reflector bulb place just in front of the wizzer cone. The pictures explain more. Happy experimenting!



Update November 2005

Feedback from a Solo-206 owner: *"I tried the wire grounding the - lead to the speaker frame trick. What a startling change in the clarity. The higher frequencies are very much improved and I hear sounds that were not audible before. Two persons asked me what had changed on hearing them after the modification. When I modified the first speaker, I soldered the 12 awg, Ag plated, 26 strand, Cu wire with teflon jacket (Army surplus) (a bobby pin is probably as good) to a place on the frame where I had sanded down to the metal. When I looked at the photo on your website I noticed you had soldered to the rivet holding the standoff to the frame. It made more sense so I did that on the second speaker. After listening with a friend (aware of the modification but not the difference) we were both convinced that the first speaker to be modified was the better sounding. I therefore resoldered the wire on the second speaker onto the frame. It is a bit difficult getting the frame hot enough for a good joint. Dominique Paré, Canada."*

NOTE: This design is strictly for the home DIY enthusiast and not to be used professionally without my permission!

Tony Gee, The Netherlands

May 2003, updated January 2005, February 2005, November 2005