The Coral Flat 10 II driver in a ported enclosure

I started this project as a way of getting high sensitivity speakers within a limited budget. While there are some lovely, sensitive speakers on the market, I can’t afford them. So, I decided instead to build some bass-reflex enclosures around a pair of second hand Coral Flat 10 II drivers. Made by the now (sadly) defunct Coral Audio Company of Japan, the Flat 10 II is a (nominal) 10 inch diameter full-range driver, the lower-rated (and more affordable) cousin of Coral’s now legendary Beta driver. As far as I’ve been able to find out, production finished in the mid 1980s.

I used Juha Hartikainen’s very flexible WinISD program and Martin King’s Mathcad worksheets¹ to give me an idea of what I should build. The thin line in Figure 1 is the modelled frequency response of a 57 litre enclosure tuned to 50 Hertz (Coral’s and WinISD’s estimate of the enclosure giving an optimally flat curve). The thick line shows the modelled frequency response of a 135 litre enclosure tuned to 42 Hertz.

Figure 1: WinISD model of Coral Flat 10 II in a 135 litre enclosure tuned to 42 Hertz

I chose to trade an optimally flat frequency response curve for a larger enclosure extending the useable bass down to around 43 Hertz. This kind of alignment, sometimes called a ‘low frequency shelf’ or ‘extended bass’ alignment, offers some advantages when building enclosures for drivers with a low $Q_e$ (approximately 0.345 for the Flat 10 II).²

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¹ At http://www.linearteam.dk/ (thank you Juha et al) and at http://www.quarter-wave.com/ (thank you, Martin). Thanks also Patrick Turner for encouragement and advice (http://www.turneraudio.com.au).

² Steve Spicer has an interesting discussion of the pros and cons of the extended bass alignment for low $Q_e$ drivers (see http://users.bigpond.com/tunnelgap/Tannoy/lowq.html).
I checked the WinISD results using Martin King’s Mathcad worksheets, which allowed me to tinker with the position of the driver relative to the port so as to minimize the blips and dips up to 1000 Hertz. After some trial and error, I decided to centre my driver 150 mm from the top of the inside of the enclosure and the port at 685 mm down from the driver. I selected a port 115 mm long with a diameter of 150 mm as a first “best guess”, allowing myself the luxury of tuning using ports of other lengths. The photos below show the layout of the baffle board and driver.

I wanted to discourage standing waves and reflections, but a moment’s consideration of my nonexistent joinery skills convinced me that I’d not do a good job of building an ideal enclosure with tapered walls, top and back: a complex shape was out. Instead, I opted for a square cross-section truncated by a baffle at 45 degrees to the sides, so that the rear of the driver fires towards angled walls, minimizing the direct reflection of signals back onto the driver. All I need cut was a 45 degree chamfer top to bottom on either side of the baffle. The overall enclosure design can be seen in the photos overleaf.
The picture on the right also shows the layer of acoustic absorption foam on all the inner surfaces of the enclosure, intended reduce reflections and standing waves. After a fortuitous conversation with Mike Latimer of Latimer Acoustics,\(^3\) I installed their 50 mm polyether acoustic absorption foam (its trade name is Acoustop). The foam absorbs less than 15 per cent of acoustic energy below 100 Hertz, better than 80 per cent of acoustic energy at frequencies above 300 Hertz and has an overall noise reduction coefficient of 0.80.\(^4\) Polyether also resists ageing extremely well.

With the port at the front, the enclosures can be pushed back into the corner. The adjacent walls can then act, to some degree, as lateral extensions of the baffle, reflecting diffracted signals back toward the listener. This is likely to be most effective at lower frequencies. Wavelengths under about 1 kHzertz are at least as big as the diameter of the driver and baffle, so that they tend to bend back around the enclosure almost as readily as they travel forward toward the listener. Using the walls as extensions of the enclosures helps direct bass toward the listener and tends to reduce the roll-off at low frequencies.

The next photo shows my daughter sitting in front of one of the basic enclosures the morning after I put them together, early in February 2005. When my partner saw them, she was appalled at their ugliness and their size. I assured her that they’d look better when finished and then played Vika and Linda Bull singing Paul Kelly’s *99 years* (Mushroom 335122). She was moved almost to tears, saying that she’d never have thought that these ugly boxes could make such a *difference* … phew … we played more recordings over the next half hour with growing enthusiasm.

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\(^3\) See their site at http://www.acoustop.com.
\(^4\) The test procedure was conducted by the University of Canterbury against ISO 354-1988 – technical specifications courtesy of Latimer Acoustics.
Here’s a sample of our listening impressions so far. It’s now an effort to listen to *Sympathy for the Devil* from *Beggars Banquet* (Decca SKLA-4955). The bass is too thin and, while both the vocals and Brian Jones’ guitar are excellent, they are too forward. By contrast, *Dear Doctor* from the same LP has now come alive, boozy backing vocals and all. The engineer, Glyn Johns, must have changed a thing or two when, not too many years later, he recorded *Who’s Next* (Polydor SPELP 49). It is revealed as clear and gutsy with plenty of bass from the late, great John Entwhistle. In fact, these speakers seem to reveal good bass as recorded, without smudging or fudging a sort of “lowest common denominator” bass sound. Other fine examples are Midnight Oil’s bass on *Diesel and Dust* (CBS 4600051), the Stone Roses on *Second Coming* (Geffen 20642 45031) and ZZ Top on *Fandango* (London BSK 3271). It seems that, if the bass was there in the first place, these speakers will let you hear it: otherwise, not.

Leo Kottke’s debut (Takoma TAK-7024) is now refreshed and utterly engaging. By contrast, his first Capitol recording (*Mudlark*, ST-682) now sounds a little over-produced and flat in places. John Martin’s tired and grief-stricken vocals on *Maree’s Wedding* (*Sunday’s Child*, Island L35453) are rescued from oblivion and Sandy Denny’s overdubs on *The Quiet Joys of Brotherhood* (*Sandy*, Island IL34697) are now distinctly separated rather than a blurred chorus. Taj Mahal’s *Giant Steps* sounds gritty, sly and sexy by turns with much improved percussion (Columbia CG 00018). And Van Morrison’s *No Guru, No Method, No Teacher* (Mercury 830 077-1) has been resurrected for the sake of its clarity, craftsmanship and for the sheer emotion now evident.

Fauré’s *Requiem* (HMV SAN 107) now displays a lot more detail, especially echoes, reverberations and other details that add a definite presence to the music and make it quite moving. The same is true of the Borodin Quartet playing Shostakovich’s 12th and 13th quartets (Melodiya CM03223-4) and a more recent recording of Derevianko’s
transcription of the 15th Symphony (DGG 00289 477 5442), the latter showing off percussion and drums in particular.

These speakers are very kind to all forms of be-bop, most traditional jazz and most old recordings. Ella Fitzgerald and Louis Armstrong (Verve 825 373-1) sound like “sitting in front of a warm fire”, according to one friend, who also particularly enjoyed Thelonious Monk playing Duke Ellington (Riverside OJC-024). Turning to modern recordings, Miles Davis’ *Bitches Brew* (Columbia 66236) sounds very good indeed, as does Miroslav Vitous on *First Meeting* (ECM 1145).

However, the verdict is that the mid-range is too bright and forward, the bass a bit woolly at times and the highest frequencies are missing. The verdict on mids and highs is certainly confirmed by the measured in-room response, shown below in Figure 2.

**Figure 2: Measured in-room response 30Hz to 16kHz**

![Figure 2: Measured in-room response 30Hz to 16kHz](image)

I measured the frequency response at an arbitrarily selected listening volume when sitting in my favourite lounge chair, well over 3 metres from the speakers. It shows that the mid-range is indeed too bright and confirms the roll-off of the highest frequencies. There is a 100 Hertz hole, and rising bass at the lowest frequencies. The rising bass is quite audible (probably the enclosure stimulating the room reverberations) and I’ve been experimenting with different speaker positions and listening positions to counter it.

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5 Measurements were taken using an NTI Minilyzer and calibrated NTI MiniSPL microphone. I took the readings late at night, when the ambient noise in the room was 52dBA. All the measurements were in dBa, which I converted to dB and then compensated for the 3dB per octave roll-off which is characteristic of pink noise signals. I also used sine wave test signals and a Velleman hand-held oscilloscope to measure impedances from 20 Hertz to 20 kHz. This showed that the driver and enclosure were tuned to 38 Hertz – 4 Hertz lower than I’d intended.
I decided to ignore the 100 Hertz hole (couldn’t really think how to fix it!) and concentrated instead on designing a passive filter to sit between the amplifier and the speaker. I settled on a capacitor (3.3 μFarad), inductor (0.47 mHenry) and potentiometer (0 to 25 Ohms) in parallel (the potentiometer gives me some wriggle room). I found that setting the potentiometer at about 8 Ohms evens out the response between 1 kHertz and 10 kHertz and the sound is no longer so “forward”.

From the listener’s perspective, the filter certainly helps redeem some recordings, notably *Sympathy for the Devil* and some older recordings of chamber music on the Melodiya label. However, the difference it makes is usually subtle and most evident over long periods of listening, which now feel “easier”, for want of a better description. And, all that said, there are some recordings that sound better without the filter – it is, after all, a simple equalizer and not all recordings are equal.

Finishing the enclosures also helped the sound. I laminated the basic boxes of the prototype (made from recycled 34 mm Laminex bench tops) with a coat of latex glue and a sheath of 9 mm MDF. The idea is that layers of material of different mechanical properties tend to reduce the transmission of vibration through the panels by friction between the layers and, for materials like chipboard, MDF and latex, by hysteretic losses within the materials themselves.⁶

I’d like to think that the laminating and removing protrusions improved the imaging but, to be honest, I didn’t notice any real change. What I did notice was much tighter bass and, once the driver was faired into the face of the cabinet using a chamfered wooden surround, everything sounded “cleaner”. They certainly sound cleaner without the grilles in place (not shown) which help to toddler-proof things.

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⁶ Tannoy discuss the benefits of lamination in the operating and service manual of their late 1980s Monitor Series.
**Summing up**

Listeners tend to agree that the imaging is quite good and that the speakers sound pleasantly engaging. This seems to me to confirm the main advantages of using a single driver to cover the full frequency spectrum. The coherence of the sound gives performers individual locations in space and “smearing” of the musical image is much reduced, compared to speakers using passive cross-overs. On the other hand, asking one driver to cope with everything from 20Hz to 20kHz is a bit much. I think *6moons* reviewer Jules Coleman put it quite well when he said:

> If you have spent any time with full-range drivers and do not suffer from denial, you know that you are missing two things: extension at the frequency extremes and weight. Many people ignore the problems; others make peace and keep their speakers long-term.

Well, for about $1,000 in parts and materials, I’ve been quite happy to make my peace … and I’ve very much enjoyed the journey, as they say.

Kim Bond, July 2006