KOZO

A High Performance Compact Three Way

Jason A. Petrasko - jupiterspeakerworks.com

The following pages detail everything needed to construct the Kozo, a compact three way with exceptional balance and ability to resolve detail. The design came about as perhaps the ninth or so revision of ideas for a contest. Called the "Micro 3-way" contest, the rules were simple: Build a three way; Use two hundred dollars or less in drivers, use half a cubic foot or less box size, and the crossover may not be outboard. Since the contest I have done a single tweak to this design, and that single addition of a bypass capacitor in the tweeter filter really dialed the sound in to the zone.

The build is not particularly cheap. As of the time I write this, the costs for a pair break down like so: 210$ for drivers and waveguide, about 120$ or more for the crossovers, and then your wood and misc. construction costs. I'd bill the total at about 400$, which is not a small amount for a speaker you have to build yourself. However I feel the performance is worth the cost in this case (I don't always feel that way about my own designs, for the record).

After covering all the design details I'll come back around and talk about most of my design choices and their reasons. I'll also describe the process I used to make the faux distressed metal finish in case that style interests you.

Driver & Components List

While the three drivers are available from parts-express.com and various vendors, the custom waveguide/faceplate is only on the 3d printing site shapeways.com, link below.

2x Dayton RS180P-4 6.5" Woofer

2x Tang Band W3-315E Magnesium 3" Fullrange

2x Vifa OX20SC00-04 3/4" Silk Dome Tweeter

2x Shapeways 3D Printed Kozo 0X20 Faceplate

http://www.shapeways.com/product/5FQ2V2SHM/kozo-ox20-faceplate-3-inch

Box and Construction

Many of the details here can be changed, omitted. However keep the box volume at just under 0.5 cubic feet total and the port the same diameter and length. You can change the box height, but increasing the width too much will adjust the midrange gain of the baffle and change the sound slightly.

Outer Box Dimensions:
15" H, 8" W, 10.5" D
Inner Box Dimensions:
13.5" H, 6.5" W, 9.5" D
Box Volume (before drivers, ports, etc)
0.482 Cubic Feet, ~13.5 Liters
Port Diameter, Length, Tuning
1.5" D, 4" L, ~42 Hz
Box Model F3, Power Handling
42 Hz F3, 60 Watts, 103.7db > 35 hz

You can squeeze a little more out of the RS180P-4 if you don't care about as much power handling or larger box size:

Alt. Box Volume (before drivers, ports, etc)
0.75 Cubic Feet, ~22 Liters
Alt. Port Diameter, Length, Tuning
2" D, 6.75" L, ~38 Hz
Alt. Box Model F3, Power Handling
38 Hz F3, 40 Watts, 102db > 35 hz

In my opinion, gaining four hertz of extension isn't worth the decrease in power handling and output. You also end up with a 50% larger box. You pay a lot for very little.

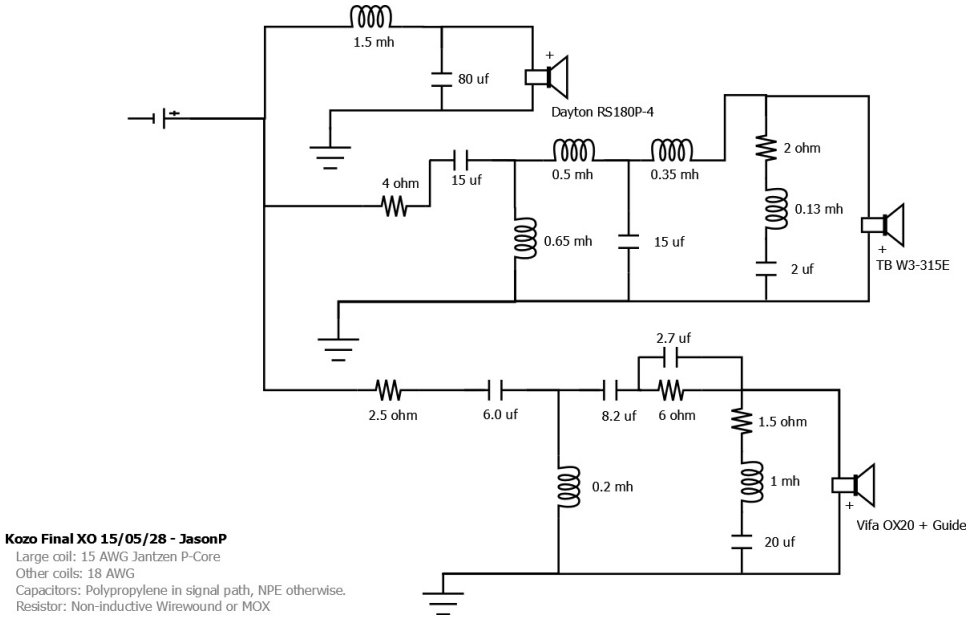
You can see in the baffle template later that the woofer in this box design is not flush mounted, but surface mounted. Its frame actually covers part of the midrange's flush frame. This is to gain maximum interior space (for the contest) and also keep the box front as small as possible. If you change the box height and width, you can easily flush mount the woofer as well to improve the looks.

The laser sintered nylon faceplate from shapeways comes with no mounting holes of any kind. You could machine three or four holes into the plate, but I invite you to gain the advantage of a seamless tweeter surround by making a tight fitting hole and using a caulk to seal the plate in. I used Loctite PolySeamSeal, an adhesive caulk with excellent gripping power. I also used the same caulk to mount the OX20 to the guide itself.

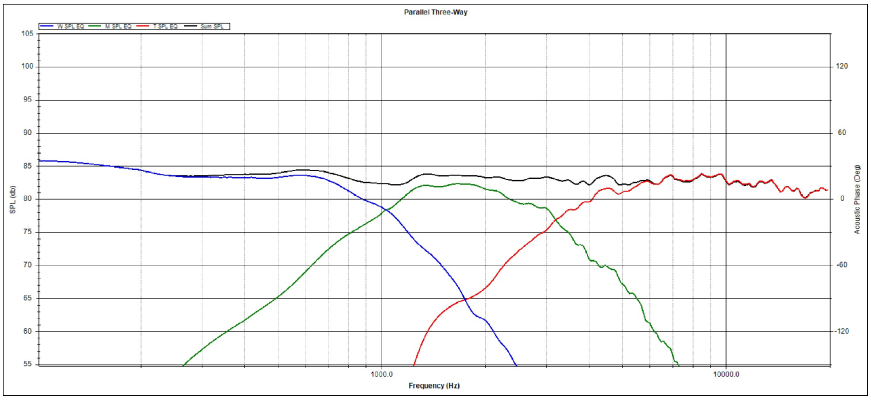
The midrange needs its own sub-enclosure to work properly. Anything you want to use that is about 0.5 liters (30 cubic inches) should do. I used a small ceramic flower pot that I caulked onto the baffle with the same caulk mentioned above. This enclosure should be full of stuffing, to absorb the back wave totally and lower the Q of the small space.

Crossover and Notes

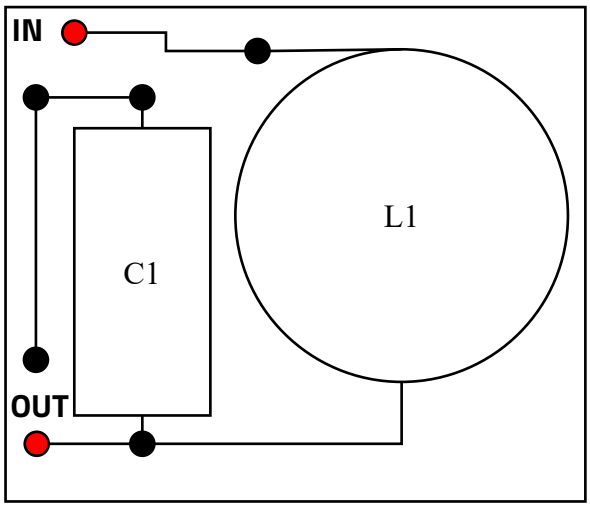
I attached the crossover board schematics after this text. If you want to use the same parts for the design, you can print and use those layouts to make boards. Exact parts-express.com number for each component can be found there.



There is the crossover conventional schematic. Note that if you print the circuit boards, you still will need to add the two parallel circuits after the crossover on both the tweeter and midrange. Those are an impedance notch and breakup notch respectively, but I keep them separate in my builds from the crossover boards. It is a twenty component crossover in total which isn't small by any means, but that is what it took to dial it in. Let's look at the response gained from such attention to detail:



Kozo Circuit Board Schematics



Woofer Circuit Board

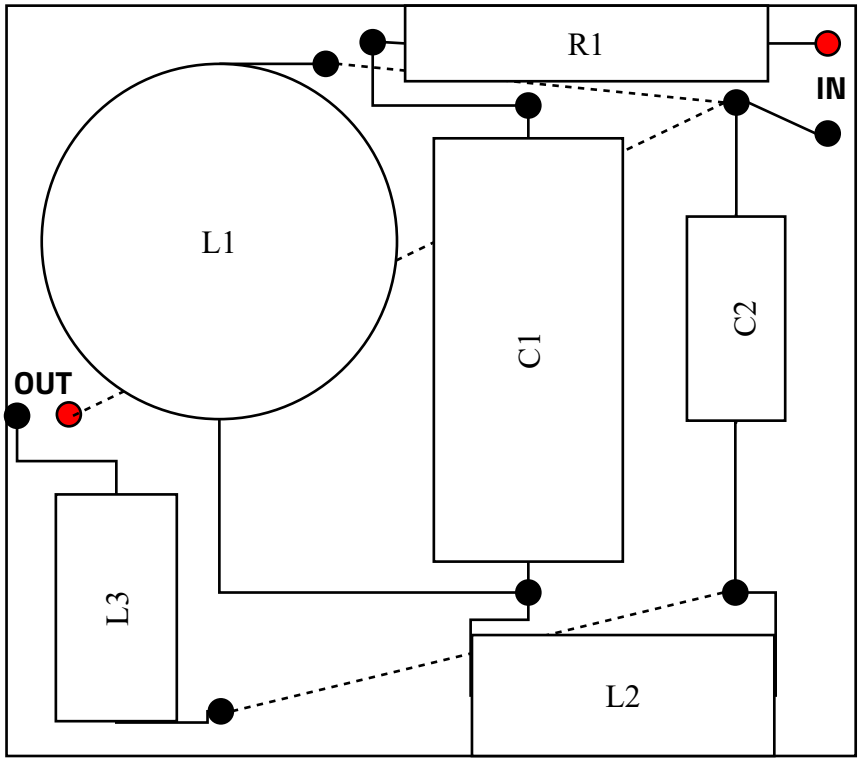
Dimensions: 76 mm x 65 mm,
3" x 2.55"

Parts List:

- C1: 80uF 100V Electrolytic Non-Polarized Capacitor
- L1: Jantzen Audio 1.5mH 15 AWG P-Core Inductor

Parts-Express Numbers:

- C1: 027-358
- L1: 255-104



Midrange Circuit Board (Note Reversed Polarity)

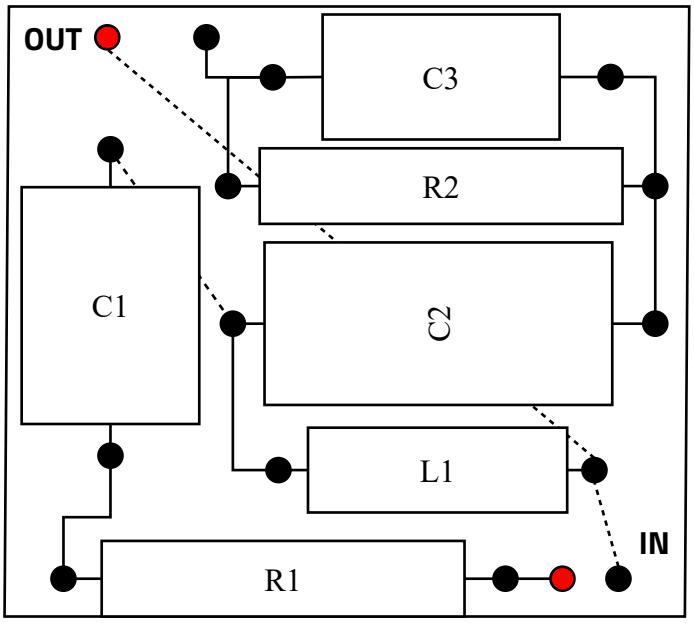
Dimensions: 112 mm x 100 mm,
4.4" x 3.9"

Parts List:

* C1: Dayton Audio DMPC-15 15uF 250V Capacitor
* C2: 15uF 100V Electrolytic Non-Polarized Capacitor
* L1: Jantzen Audio 0.65mH 18 AWG Air Core Inductor
* L2: Jantzen Audio 0.5mH 18 AWG Air Core Inductor
* L3: Jantzen Audio 0.35mH 20 AWG Air Core Inductor
* R1: Dayton Audio DNR-4 Non-Inductive Resistor

Parts-Express Numbers:

* C1: 027-432
* C2: 027-344
* L1: 255-236
* L2: 255-230
* L3: 255-030
* R1: 004-4



Tweeter Circuit Board

Dimensions: 90 mm x 81 mm,
3.55" x 3.2"

Parts List:

* C1: Dayton Audio DMPC-15 6.2uF 250V Capacitor
* C2: Dayton Audio DMPC-15 8.2uF 250V Capacitor
* C3: Dayton Audio DMPC-15 2.7uF 250V Capacitor
* L1: Jantzen Audio 0.2mH 20 AWG Air Core Inductor
* R1: Dayton Audio DNR-2.5 Non-Inductive Resistor
* R2: Dayton Audio DNR-6 Non-Inductive Resistor

Parts-Express Numbers:

* C1: 027-427
* C2: 027-426
* C3: 027-416
* L1: 255-024
* R1: 004-2.5
* R2: 004-6

Design Choices and Finish

Let me see if I can shed light on why each driver was chosen and how it was applied. I'll start from the woofer and work up the response spectrum.

The RS180P-4 is the initial design choice. I had wanted to use this driver for a while. My first RS driver success was using the RS100P, a very nice small midrange and I wanted to explore a larger driver with more bass output. The name of the speaker takes from the paper cone of this newer woofer. Kozo is the Japanese name for the Paper Mulberry Plant, considered by most historians to be the original form of paper as used by the Chinese people long ago. The name Kozo is an homage to paper itself. I chose the 180P-4 specifically because the specs looked good for some nice bass. A lot of the new P line are very nice, but they don't model well for bass extension as compared to their aluminum cone older sisters.

The W3-315E was on sale, and at the price looked to be a knock-out midrange. I had just heard another Tang Band mid in a design by CJD that sounded amazing and wanted to try one in a design. It fit the budget of the context, and responses looked good on paper. When I tested it though, it has highish distortion below 600 hz and above 4000 hz which really limited is usefulness in all but a narrow midrange scenario. In the range I use it though, 900 hz to 3.5 khz, it is a world class performer. I really like the sound of it, and think it remains very neutral, never drawing attention to itself.

The OX20 I've used more than once. Simply put, it doesn't do anything wrong. It has a modern neo slug motor, optimized chamber, and an amazing product consistency (every one of the eight I have used have measured spot on). I had designed the shallow curved waveguide faceplate after the CSS LD22C, and wanted to use it for a while. I jumped at the chance here to use it in this design. The guide gives the tweeter a boost from 5khz and up of about 3db, which makes the crossover harder. On the other hand, the measurements on it are the smoothest I've ever seen for the OX20. It really minimizes the interactions of the baffle on the tweeter and removes a lot of the jaggedness you'd see normally.

The finish for my pair is a reflection of my love of metal. I am working over the years on refining the perfect distressed or hammered metal look. Lucky for me very convincing Modern Masters Metallic paints exist, and I used these in this build. The process for the finish is as follows:

1) Create and apply the texturing material to the sanded box with a scraper, leaving it rough. Sand down that material when dry (wait a day).

2) Seal the texturing material with a nice oil based primer. I used Kilz Original. Sand that down with 400 grit gently when dry, clean dust off.

3) Spray a base coat of shiny black metal with Rustoleum Hammered Black spray and let that dry.

4) Use two tones (dark and light) of a Modern Masters Metallic paint (I used Antique Copper and Copper). Brush it onto a palette thinly, apply with a sponge gently to get a dry brush effect without brush marks.

The texturing material I used was a mix of Durham's Water Putty, Titebond III glue, and water in a 10:4:3 ratio by volume respectively. This creates a tough, adhesive putty to apply to the box. It begins to dry in minutes though, so you have to work with some speed.