Back

The Short Line Array

By Bill Fitzmaurice

This line array will fit your space requirements as well as your budget.

I've had several requests for a small high-sensitivity speaker good for either hi-fi mains, control room monitors or, most especially, home theater (HT) center channel. One of those requests came from me. Ever since I outfitted my HT with TLAH mains and a T18 sub, I haven't been able to hear the center channel well enough, as the 87dB sensitivity of my MTM center just wasn't enough to keep up. Obtaining more sensitivity with a line array was the obvious answer, but like most of you I also don't have room for another 3′ long plus cabinet in my entertainment center.

I decided that the largest box I could tolerate was 26″ long, about 7″ high, and 6″ deep. So was born the short line array (SLA). Short it may be in size, but in sensitivity and response it's right up there with the big boys, as you can see in the SPL chart (**Fig. 1**).

FEATURES

One advantage of a line array is that you can use many inexpensive low-powered drivers to produce high sensitivity. Another is that you can have a very good-sounding cabinet for very little money. When searching out drivers to use in this project, check out the web for specials and closeouts.

The woofers I used in the original were 4″ Pioneer "NSB" closeouts from Parts Express, part # 269-568, which I purchased for 49 cents apiece. Specs are f_S 105Hz, Q_{TS} .76, V_{AS} .1ft^3. The tweeters were Onkyo closeouts, part # 269-780, 24 cents apiece. These tweeters have no mounting flanges, so you must glue them in place. There are many variations of this Onkyo tweeter available, some with coaxial mounting frames that you can discard.

Also note that these tweeters have three wiring lugs; the middle lug is not connected to the voice coil, so ignore it. If you use different drivers, it is critical that the woofers have squared-off "pincushion" style frames and that the tweeters are no more than 1.5″ diameter.

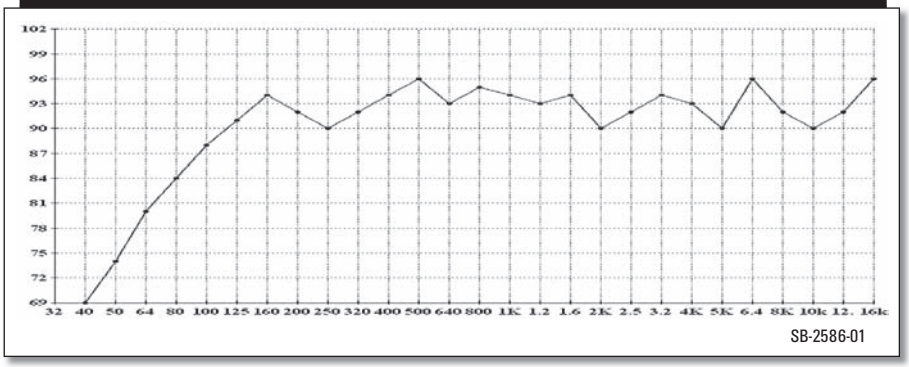
A center-channel home theater speaker is usually horizontally mounted (**Photo 1**). This can be problematic with all alignments, but particularly with line arrays, which are by design intended to be vertically mounted. However, you can still obtain very good results with the SLA. By having the woofer frames literally touching each other, and with the minimal frame width of the pincushion design, the outputs of the woofers integrate into a single cohesive wave front up to at least 4kHz.

Because the main output of HT center channel is voices, with a primary bandwidth from 150Hz to 5kHz, there is no discernible comb-filtering. Even in music applications, combing is not a serious problem when this cab is lying down, but if at all possible it should nonetheless be upright.

The tweeters are mounted on the rear of the baffle, which is normally not preferred. However, the SLA uses this scheme to its advantage. The tweeters fire through 1″ diameter holes that are chamfered with a ½″ radius quarter-round router bit, transforming each hole into a small horn. This increases the effective radiat-

PHOTO 1: The SLA.

FIGURE 1: Frequency response.



ing plane of each driver, minimizing the frame space between them to aid in their wave-front integration. Even without this feature, the close-spacing of their acoustic centers guarantees wave-front integration to at least 7.5kHz, but with it they work even better.

CONSTRUCTION

Because the woofers are so close that their mounting holes overlap, and because of the routing of the tweeter micro-horns, you should make the SLA baffle out of solid wood. Its size is a standard 1 × 8, which actually measures 0.75″ × 7.25″. Any wood will do, though you'll probably prefer to use something that matches the rest of your system. You can use solid wood for the rest of the cabinet, but plywood or MDF is OK as well. I used red oak for my baffle, along with 0.75″ red oak veneer plywood for the rim of the box and scrap plywood for the back.

With the close spacing of the drivers, it would be very difficult to wire them and seal them to the baffle with cabinet sides in place, so construct the cabinet with a permanently installed back and a removable baffle. This requires a bit of specialized hardware, though not so special that you can find it at any well-stocked hardware store: threaded inserts (**Photo 2**). Drill a hole in the edge of the box and drive in the insert with a screwdriver or Allen wrench—depending on the design—and you have an easy way to bolt the baffle to the rest of the box.

Start construction by cutting out the baffle. Its finished size is 26″ long, but cut it slightly longer to allow for trimming after assembly. Draw two

FIGURE 2: Baffle view.

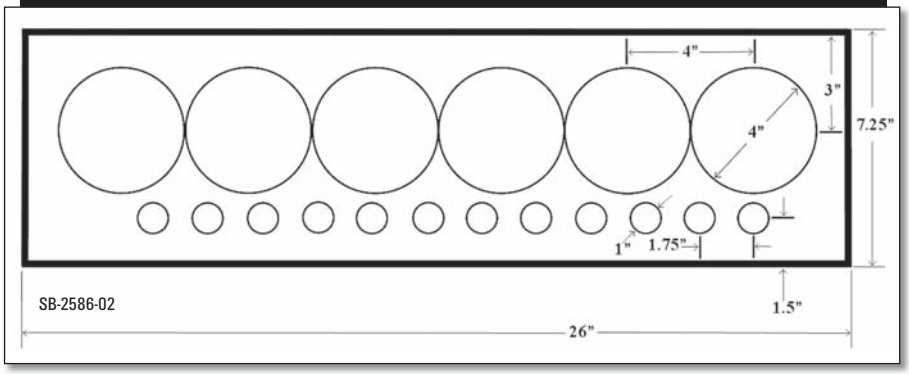
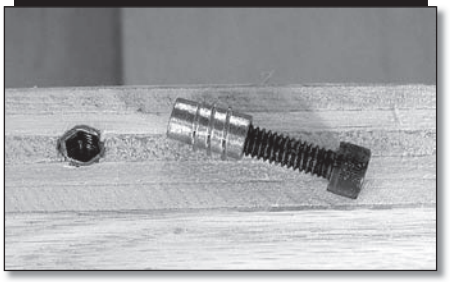


PHOTO 2: A threaded insert, Allen head bolt, and insert mounted in the box side.



horizontal lines on it—one 3″ from the top edge and one 1½″ from the bottom edge. These form the axes for the holes for the woofers and tweeters, respectively. The woofer holes are 4″ diameter, 4″ on center, the tweeter holes 1″ diameter, 1¾″ on center, as shown in **Fig. 2**.

PHOTO 3: Baffle rear view. Note the reduction of the baffle thickness where tweeters will be mounted, and chamfering of woofer holes.

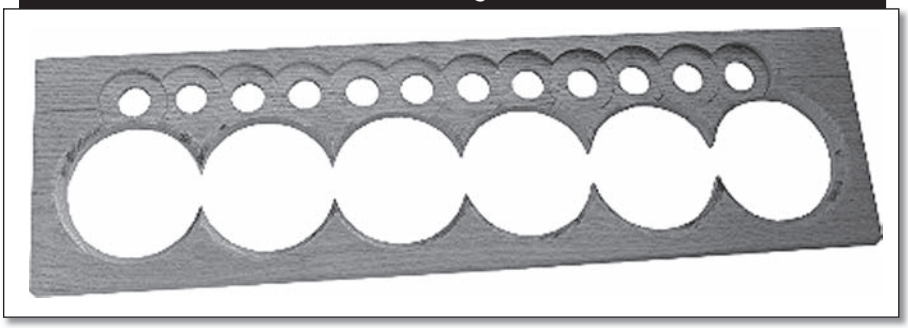
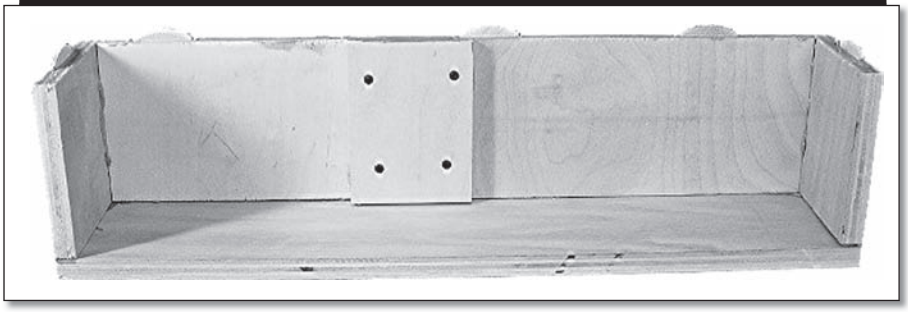


PHOTO 4: Assembling with biscuits



Drill the first tweeter hole with its center 3″ from one end of the baffle, as is the first woofer hole. If you're building a pair of these as stereo mains, you should make them mirror-images of each other. Before drilling the tweeter holes, you need to reduce the thickness of the baffle where they are to be mounted by approximately 3/16″. You can do this with a router or a drill-press-mounted Forstner or spade bit.

I used a 1½″ diameter spade bit, leaving ¾″ of material at the edge of the baffle undisturbed. Then drill out the 1″ diameter tweeter holes and rout them from the front side with a ½″ radius quarter-round router bit. Using the same router bit, from the inside of the baffle, put a chamfer on the woofer holes as well, without which it would be almost impossible to get at the woofer frames later on when they need to be sealed to the baffle (**Photo 3**).

Now cut out the back, sides, and ends. Their dimensions depend on the thickness of the material they're made

from. The back is the same nominal size as the baffle less the thickness of the top, bottom, and sides. Therefore, with ¾″ material the back will be 26″ less 1.5″ long, for a net of 24.5″, and 7.25 less 1.5″ wide, for a net of 5.75″ wide.

Cut the back perhaps a sixteenth of an inch undersize in both dimensions, so that the top can be trimmed to the exact size of the box after assembly. You can make the back from whatever scraps you may have, even jointing it with a backer piece over the joint if required. Cut the ends to the exact width of the back by 5″ deep, so in the case of ¾″ material that would be 5″ by 5.75″. They attach to either end of the back by whatever means you prefer, be it glued and screwed, nailed and screwed, or even just glued. On my prototype I used a biscuit jointer, which gives very strong perfectly aligned joints with no visible fasteners.

Next come the sides, cut to be as long as the finished length of the back/ends assembly, and 5″ wide. Attach these to the assembly via the same method as with the ends (**Photo 4**). After applying the second side, clamp the unit thoroughly while the glue sets (**Photo 5**).

PHOTO 5: Clamps, clamps, and more clamps.

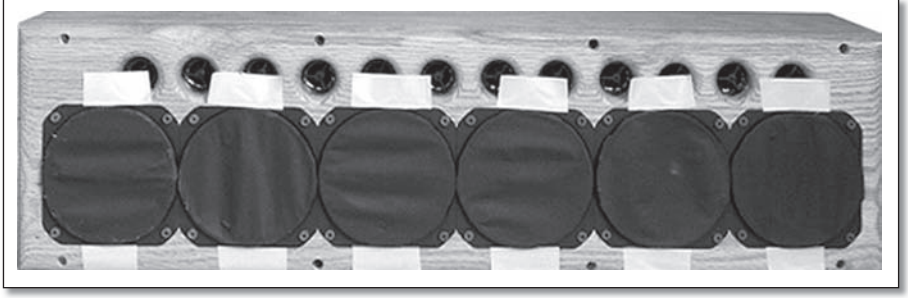
ASSEMBLY

When the glue has set, use a couple clamps to hold the baffle in place. On its face, mark where the attaching bolts will pass through it, evenly spacing six to eight of them around the box perimeter. Using a drill bit the same diameter as the bolt, drill through the baffle and about 1″ beyond into the box frame, preferably using a drill press to ensure the holes are perpendicular. Remove the baffle and re-drill the holes in the box frame, this time with a bit large enough to accept the inserts. Screw the inserts in place, driving them slightly below the wood surface.

Coat their exterior with a few drops of epoxy before installation to better secure them, but don't use so much that it oozes and fills the threads; if that does occur chase them clear after the epoxy sets with a thread chaser/tap. Using a drill bit one size larger than the bolt head, countersink

PHOTO 6: Cutaway of a countersunk baffle bolt hole.

PHOTO 7: Masking the woofer/baffle joint for sealing.



the holes in the baffle about halfway through, so that even after chamfering the baffle edge the bolt heads won't extend beyond the surface (**Photo 6**). Bolt the baffle to the box.

Use a router with a flush trimming bit to trim the baffle flush with the box; if you don't have one, use a sander instead. Likewise, use a quarter-round bit to chamfer the baffle edges to a ½″ radius; otherwise, use a sander. In either case proceed to installing a port. Depending on how you plan to mount the cabinet, you can put the port in either end of the box or on the back.

The port is simply a 2″ diameter hole; there is no duct required. If your port goes through ½″ cabinet walls, a simple hole will do, but if it goes through ¾″ material, chamfer it on the outside to a ½″ radius. Also decide on a location for a jack or binding posts, again depending on how you plan to mount it, and drill the necessary hole or holes in the box. Sand the box completely and apply your finish of choice. I did mine with Tung Oil, which looks very good on hardwoods and is as easy and foolproof a finish as you'll find.

Remove the baffle and install the drivers. The woofers install from the front, attached with ½″ screws. The tweeters install from the back, glued in place with a hot-melt glue gun.

Install the tweeters first. Hold a tweeter in place, checking its alignment while looking through its hole in the baffle, and then tack it into position on the baffle rear with a couple of drops of glue, holding it steady until the glue cools enough to secure it. Then fully seal the tweeter frame to the baffle, leaving no gaps. Do each tweeter in kind, being sure to have the lugs aligned in the same direction, and so that they don't hit either the woofers nor extend into the joint between the baffle and the box.

When you have done the tweeters, mount the woofers. You may wish to spray-paint the woofer frames first. If so, shield the cones with masking tape, leaving the tape in place when you're done to protect the cones until the cabinet is completed.

FINISHING TOUCHES

It's likely that there will be some gaps between the woofer frames and the baffle, so use masking tape to fully cover those gaps (**Photo 7**). From the inside of the cabinet, caulk the joints of the woofers and baffle and those of the woofers to each other as well. A small tube of almond tub and tile caulk works fine. After the caulk has set, remove the masking tape from the front of the baffle.

Wire the drivers, using polarized loudspeaker wire. Connectors are OK, but I prefer soldered joints, and that's much easier to do if you stay with 16 or even 18 gauge wire. There's not enough current flowing in this box to justify anything heavier, especially with the tweeters.

The woofers are marked with a + on the positive lug, but the Onkyo tweeters are not. Instead you'll see a spot of blue paint on the magnet near the positive lug. The impedance of the woofers is 8Ω, so they are wired as two series-wired banks of three woofers in parallel, for a total 5.6Ω load.

The Onkyo tweeters are 6Ω each. They run a bit less sensitive than the woofers, so they're wired as four parallel-wired banks of three series tweeters, giving an impedance of 4.5Ω and matching the sensitivity of

FIGURE 3: Wiring schematic.

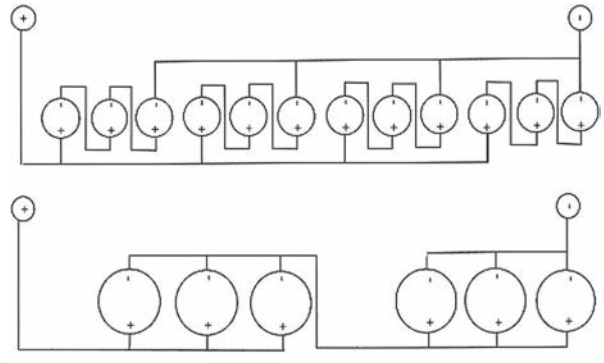
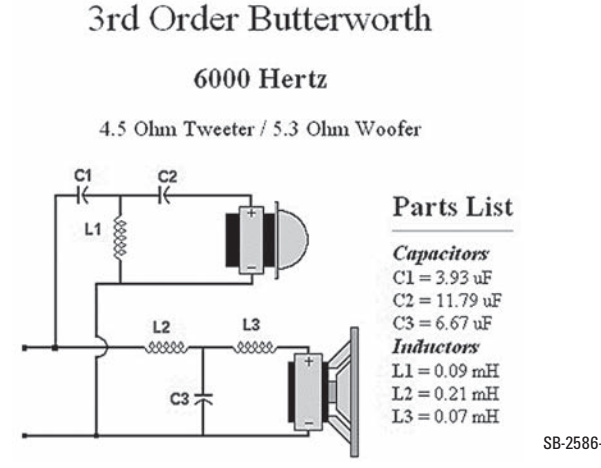


FIGURE 4: Crossover schematic.



the tweeter line to that of the woofer line (**Fig. 3**).

The crossover is a third-order at 6kHz (**Fig. 4**). When ordering your components, you can safely go within 10% of the listed values. C1 and C2 must be poly caps, but since C3 is merely a shunt you may use a less expensive electrolytic there if you wish.

None of the inductors are of a high enough value that their DCR is of much concern, so 18 to 20 gauge air core coils will do just fine. Using hot-melt glue, mount the crossover components in the box, keeping the coils well apart and oriented on different axes to minimize crosstalk (**Photo 8**). Wire the crossover input to your input jack/binding posts, and use a pair of fairly long wires to connect the outputs to the drivers.

Reflections inside the cabinet will cause ragged response, so loosely fill it with polyester pillow stuffing to damp them. Place the baffle over the box and check to be sure that no wires or driver lugs are caught in the joint between the baffle and the box. If the fit is not quite perfect, use a strip of thin foam weather strip to ensure an airtight connection. Bolt the baffle in place. It's done.

For center channel use, the f3 at 125Hz is quite adequate. For music or for HT mains, SLAs must be used with a sub, with a crossover between 100 and 125Hz for the most part. However, if your sub happens to be a Tuba 18 it has much higher sensitivity in the crossover area than the SLA, so you will find that setting the low-pass frequency on the sub amp at 80Hz or even less will give the best results.

The woofers I used have shielded magnets, obviously intended for center-channel duty, but the tweeters do not. As small as they are, the tweeter magnets still are strong enough to disturb a CRT if placed too close, especially if you don't add bucking magnets. To help prevent this, place the tweeter line to the outboard side of the cabinet with reference to the TV screen. In my case no amount of fiddling prevented the speaker from interfering with the TV until I put it above the screen and laid it on its back, aimed upward. Interestingly enough, it sounds just fine. *aX*

PHOTO 8: The crossover.