

The Tuba 24 II

You don't need to be a professional DJ to appreciate the performance of this noted speaker designer's latest horn-loaded sub.

By Bill Fitzmaurice

Much has happened since I introduced the Tuba 24 pro-sound sub (*aX*, April 2004). I'm now working full-time as a loudspeaker designer, and my website, www.billfitzmaurice.com, is one of the busiest DIY speaker sites on the web.

As for the Tuba 24, the first of what turned into an entire line of DIY horn-loaded pro-sound subwoofers, it and its siblings have become the subs of choice of professional DJs. Not just the DIY subs of choice, but the preferred subs, period. Attesting to their popularity is a single thread at www.djforums.com devoted primarily to Tubas that stretches back to January 2005, with over 3500 posts and 65,000 views. But as good as the Tuba 24 is, there's always room for improvement, and thus the Tuba 24 II (Photo 1).

NEW FEATURES

The new version leaves behind the vertical baffle of the original, in favor of a horizontal baffle that allows more leeway in your choice of cabinet widths and driver complement. The side measurement, 24" x 24", is the same as the original, as is the path length and phase response, so you may use the old and new versions together. But whereas the original could only be built 24" wide, you can build the T24II as narrow as 16" or as wide as 30". For best results, you should use the T24II in multiples of two. Because the 16" wide T24II weighs only about 38 lbs, carrying two is a one-man job.

The recommended basic driver is the Eminence Basslite S2010. Pertinent T/S specs are f_s 46Hz, Q_{ts} .31, V_{as} 63 ltr, X_{max} 4mm, and P_e 150W. An upgrade

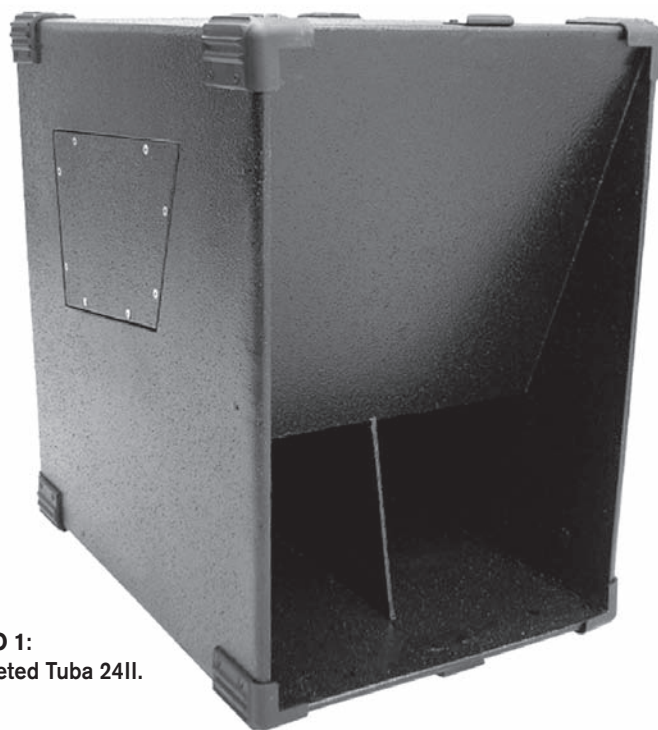


PHOTO 1:
Completed Tuba 24II.

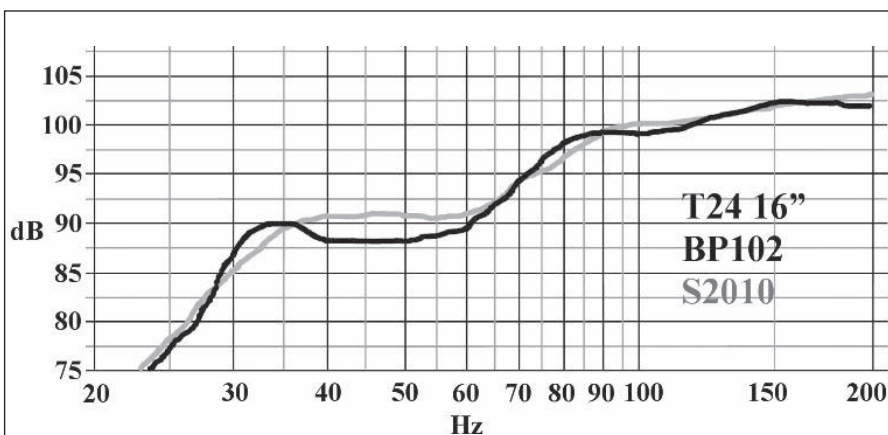


FIGURE 1: Comparison of S2010 and BP102 drivers.

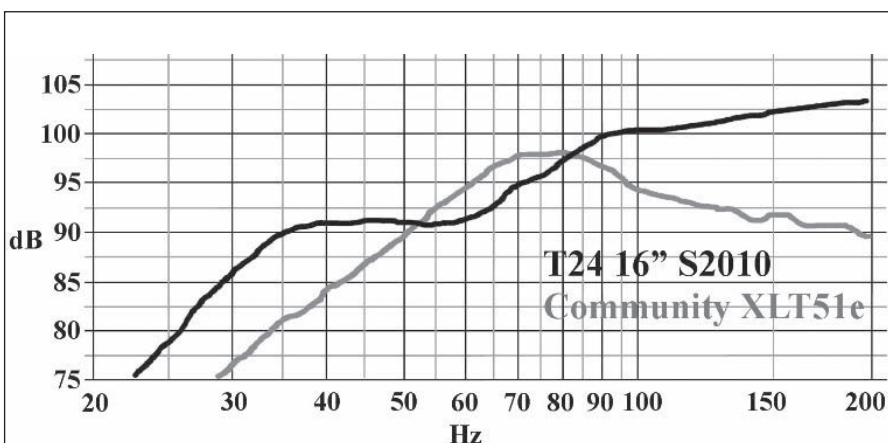


FIGURE 2: T24II and Community XLT51e.

is the Eminence BP 102, which has a 6mm Xmax and 200W power handling.

Figure 1 shows the 1m/2.83V half-space response of a 16" wide cab loaded with S2010 and BP102 drivers. The BP102 is less sensitive, but will handle twice the power before exceeding Xmax, so it's the better choice for high output situations. You can get the Eminence drivers, along with all the other hardware required for the project, at www.partsexpress.com, www.bltsound.com, and Langford Audio Systems (e-mail LawLangford@AOL.com) in the US, and www.loudspeakers.ca in Canada. The 150W rating of the S2010 may seem low, but the T24II has far higher sensitivity than direct radiator subs.

Figure 2 compares a 16" wide T24II, S2010 loaded, to a similar size 15" loaded direct radiating sub, the Community Sound XLT51e. The T24II's average 6dB sensitivity advantage gives it the ability to produce as much output as two direct radiator cabs driven with twice the power.

The cabinet is primarily made from 1/2" plywood; the self-bracing design makes thicker materials unnecessary. You may use either softwood (spruce or pine), plywood, or Baltic birch. With a carpet finish I recommend softwood, because it is lighter, cheaper, and easier to find than quality Baltic birch.

Be sure your plywood has at least five plies. With a 4 x 8' sheet of plywood, you can build one 16" wide T24II, fastening the parts with 1.25" drywall screws, 1 5/8" ribbed shank paneling nails, or a pneumatic brad nailer, using 1.25" brads. Screws and/or nails don't hold the cabinet together; they merely serve to hold the parts in place while the adhesive in the joints sets.

I recommend PL Premium polyurethane base construction adhesive, applied with a caulking gun. Polyurethane adhesive expands as it cures, filling gaps to ensure the airtight seal that a speaker cabinet requires. However, urethane is also messy to work with. After applying a bead to a joint, release the pressure on the caulking gun trigger and plug the end of the tube before it oozes all over your workshop, and you.

CONSTRUCTION

Start by cutting out the 24 x 24" cabi-

net sides. On one side draw the parts layout pattern per **Fig. 3**. **Figures 4** and **5** show the nominal parts lengths and assembly order of the internals, and the cut angles at the ends of the panels. If no angle is shown, the end is square. The parts lengths assume that the material is exactly 1/2" thick, which is almost always not the case, so cut each panel to final size as it is installed, measuring the cabinet side to confirm the exact length.

The measurements shown at each bend of the horn are to the edge of the side. After drawing the joints on one

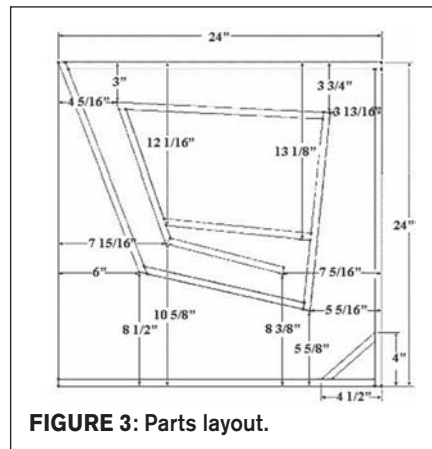


FIGURE 3: Parts layout.

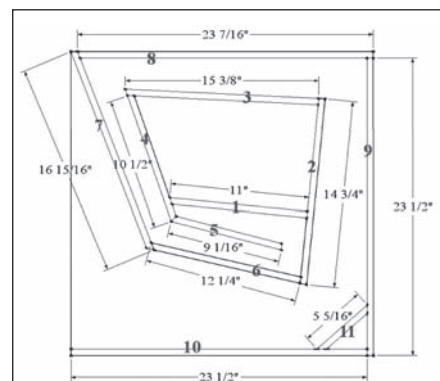


FIGURE 4: Parts dimensions.

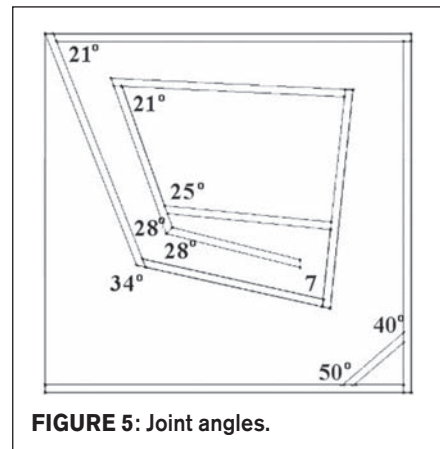


FIGURE 5: Joint angles.



Luxury Miniature high end drivers

- **50mm (2")** - Pioneered fully anodized spun Aluminum metal cone ©1982.
- **Humidity proof** ideal or tropical climate or swimming pools.
- **Unbelievable Bandwidth** covering 2/3rd of the musical spectrum accurately 150hz -20Khz , No Midrange and extra crossover resulting in a seamless sound, for the treble range.
- Reproduces complex sounds with finest clean detail.
- Harmonic distortion 1/10th that of conventional drivers.
- As fast and clean as an Electrostatic Speaker with needed added warmth.
- One driver requires only approximately 1 litres closed box (5" X 5 X 6 ") , all round sound for ceiling , walls , cars , or voice communication for treble only – require cut of protection from 150Hz down.

Show price £61 GBP each plus p&p

BANee DOReen - Doreen Bance

Email bandor@netcomuk.co.uk www.bandor.co.uk Tel +44 (0)1494 714058

side, clamp the two sides together. Drill 1/16" pilot holes through the middle of each joint. Do not drill closer than 2" or so from the end of the joint, with the holes spaced 6-8" apart. Drill the holes entirely through both sides.

If you're using a brad shooter, just drill two holes per joint, one at each end. Unclamp the sides. Draw connecting lines through the holes on the outside of each so you can easily see how the parts are laid out on the opposite side.

On the first side, draw four lines 3/8" inside the joint lines of panels 1-4, parallel to those joints, as shown in **Fig. 6**. These outline the driver access hole. To cut it, clamp or screw a circular saw sled or cutting guide to the side. Raise the saw out of the shoe, place the shoe tight against the sled guide, start the saw, and make a plunge cut. You'll want to practice this technique on some scrap wood before trying it for real.

In turn, cut each of the four lines not quite to the end, finishing the cuts with a jigsaw. Be sure you have the side raised on some scrap boards, so that you don't saw into the bench top. Put the cutout aside, saving it to use as a cover.

Cut four 1 1/4" wide pieces of plywood, sized to frame the access hole, forming

a mounting flange for the cover on the inner face of the side (**Fig. 7**). Clamp the strips in place when screwing or nailing them. The resulting hole has plenty of clearance with the S2010 driver, but the BP102 might be a little tight. If you're using the BP102 or another driver, make sure the driver fits through the hole, trimming the flange as required.

Braces connect all panels except the baffle. They may be made of 1/4-1/2" plywood, their sizes determined by dead reckoning, as shown in **Photos 2** and **3**. Place a piece of plywood of sufficient size against the inner part to which it attaches, lay a straightedge across it where the outer part will joint to it, and cut the line drawn. After sawing, lay the brace in place again to check the accuracy of its sizing.

Draw joint lines on the parts where the installed braces will join to them. The braces are not jointed end to end. If you make the braces from 1/4" plywood, dado a 1/4" wide, 1/8" deep groove down the center of each panel, to hold the brace secure while the adhesive dries. Make sure you put the groove on the correct side of the panel; panel 6 is grooved on both sides. Be sure to size the braces to account for the dado depth.

With 1/2" plywood braces you can omit the dados.

To install the braces apply adhesive to their edges and slide them into place, pushing in far enough to just be snug, using a framing square to be sure that the panels remain square to the assembly. Dado-mounted 1/4" braces don't need fastening; 1/2" braces need a couple of screws/nails/brads to hold them in place while the adhesive sets.

The approximate standard cabinet width is 16", so for minimal waste with 4 x 8' plywood, make the remaining pieces all 15 3/4" wide. If you are using a table saw, cut all the pieces to width at the same time without moving the rip fence, so they'll be identical. The rough-cut lengths of the parts follow. Cut them to these lengths initially, trimming to their measured finished size as you install each. Be sure to label them.

1. 11.25"	7. 17.25"
2. 15"	8. 23.75"
3. 15.5"	9. 23.75"
4. 10.75"	10. 23.75"
5. 9.25"	11. 5.5"
6. 12.5"	

ASSEMBLY

Panel 1 is the baffle. Cut a hole through

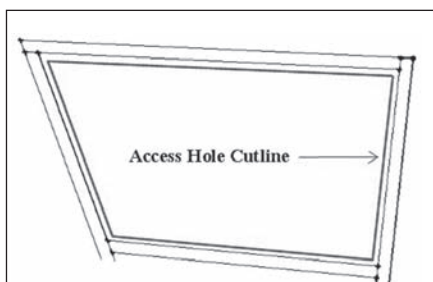


FIGURE 6: Driver access hole layout.

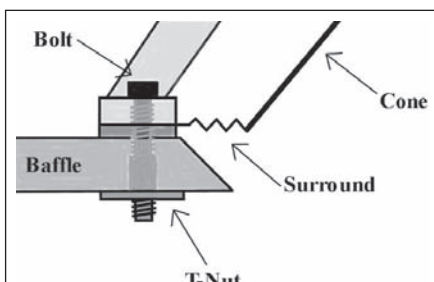


FIGURE 8: T-nut/baffle detail.

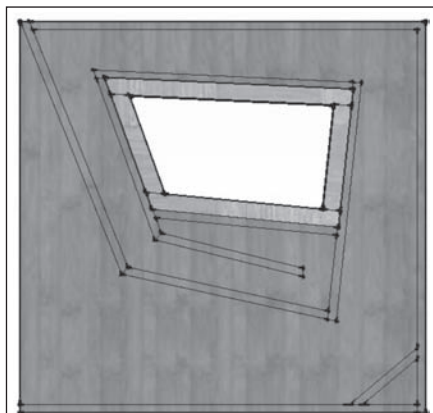


FIGURE 7: Driver access hole flanges.

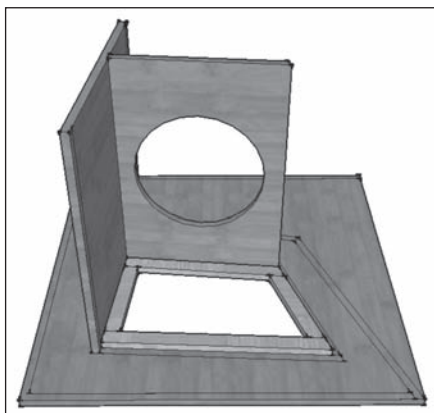


FIGURE 9: Panels 1 and 2 in place.

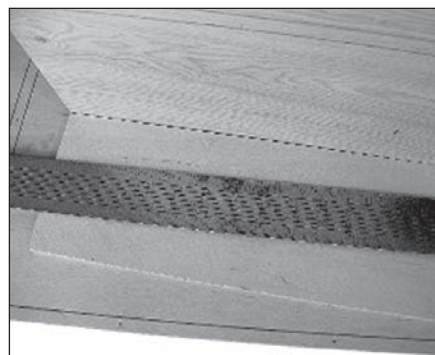


PHOTO 2: Marking brace for cutting.



PHOTO 3: Checking brace for accuracy.

it, sized according to the driver manufacturer's specifications. With lightweight drivers such as the S2010, screws are adequate for driver mounting, while 3/16" bolts and T-nuts are an option. Place the driver on the baffle, centered over the hole. Mark the screw/bolt locations through the frame holes. Put the driver aside. Drill the baffle for the screws or T-nuts.

When using T-nuts you sometimes find there isn't enough wood on the baffle to seat them well near the baffle cutout. A way around this is to mark the hole the same diameter as the inner diameter of the driver gasket, but cut the hole with the jigsaw shoe set at a 30 to 45° angle, so that the hole diameter on the opposite side of the baffle is smaller (**Fig. 8**). This leaves much more wood for the T-nut to grab.

A heavy-duty version T-nut is the Hurricane Nut, available from Parts Express. Either will work best if you coat it with some Gorilla Glue or the equivalent before driving it in, being careful not to glue the threads. Drive the T-nuts in place with a hammer, making sure that they are located on the bottom of the baffle. Trial-mount the driver to the baffle to be sure that all the nuts are properly installed, then remove it and put it aside.

Attach panel 1 to the side. The best way to fasten joints is to clamp a 2 × 2" guideboard along the joint edge, apply adhesive to the joint, clamp the panel to the guideboard, and, when all is right, screw or nail it in place. Drill screws through the pilot holes with a pilot/countersink bit to prepare the hole before driving the screw.

With nails, drill through the pre-drilled pilot holes about 1/2" or so into the panel to prevent splitting, using a nail set to drive the head of the nail below the face of the side. With panels 1 through 4 use the guideboard to hold the panel tight against the flange. Drive fasteners through the side, but don't drive fasteners into the flanges.

Cut out panel 2; attach it to the assembly (**Fig. 9**). If you're using 1/4" braces, dado panel two and all other panels for bracing before installing. Always clamp joints and check the parts alignment with a framing square to be sure they are true before driving screws or nails.

Use wood scraps temporarily tacked in place to hold the free edges of the panels in place for proper alignment (**Photo 4**).

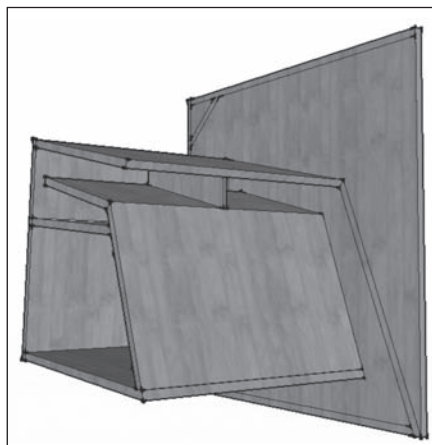


FIGURE 10: Assembly through panel 6.

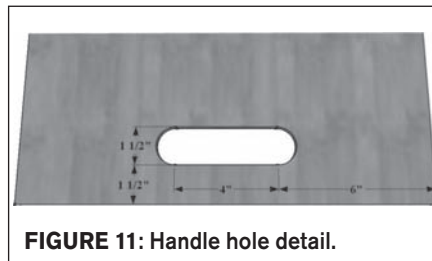


FIGURE 11: Handle hole detail.

Install panels 3 and 4, then panels 5 and 6, and the brace between them (**Fig. 10**). Install panels 7 and 8 and their associ-

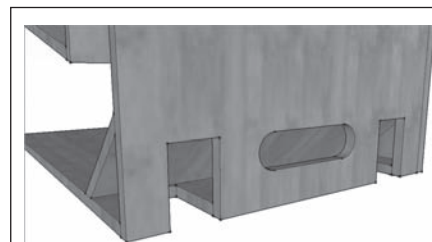


FIGURE 12: Lower back detail.

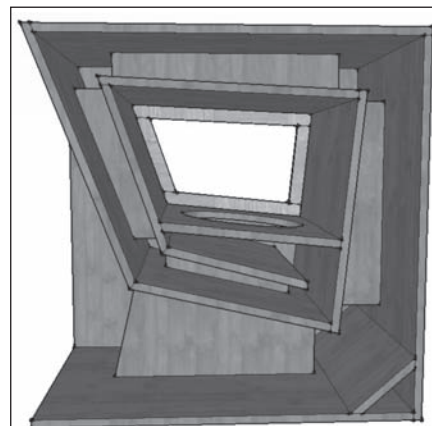


FIGURE 13: All panels in place.

**The Fullrange
Speaker Experts!
Free Plans, Parts Lists
and Setup Tips
with Any Purchase.**



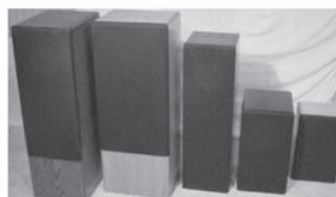
**Audio Nirvana
Lowther
PAudio
Fostex**



**Also Available:
Completely Finished Speaker Systems
Vintage Audio Equipment, Speakers, and Mics
Vacuum Tubes, Audio Literature**



Audio Nirvana from \$98/pair



Some of Our 30 Different Cabinet Designs



PAudio from \$275/pair

www.commonsenseaudio.com



Fostex FE206E ~ \$168/pair

Phone: 314-579-0088

**E-mail:
speakers@charter.net**

**David Dicks
CommonSense Audio
120 San Angelo Drive
Chesterfield, MO 63017**

**DEALER INQUIRIES WELCOME
WE SHIP WORLDWIDE**



Lowther from \$595/pair

ated braces.

FINISHING TOUCHES

The lower rear of the cab is a good place to install a pair of cutout handles. Cut them into panels 9 and 10 before installing the panels, as shown in **Fig. 11**. The cutout is produced by drilling two 1½" diameter holes 4" apart on-center, removing the material in between with a saw.

Another option is 2 × 3" cutouts (**Fig. 12**) that allow mounting 2½" casters, bolted to panel 11. Cut these also before installing the panels. Install panels 9 and 10 and their braces, and then panel 11 (**Fig. 13**).

A good spot for jacks is on the lower section of panel 9, just above panel 11. Use Speakon jacks, which have the advantage of being airtight. A pair of jacks will allow daisy-chaining of multiple cabs. You can mount them with a commercial mounting plate, or you can make your own from 3" diameter plywood discs.

Drill a pair of 2" holes in panel 11, attach the discs to inside of panel 11

over the holes, then drill 15/16" holes through the discs for the jacks. Drill a hole through panel 2 for the wire to pass through. Feed a piece of 14 or 16 gauge speaker wire from the driver chamber to the jack location, sealing the hole airtight with adhesive.

Lay the cabinet on its side. Apply a generous bead of adhesive on all the panel edges. Put the second side atop the assembly, making sure that it is oriented so that the pilot holes line up with the panels. Nail or screw it into place, using long pipe clamps to pull it into perfect alignment with the rest of the cabinet. Screws are the better option to pull the side tight to the inner panels.

Look inside the box through the driver access and the mouth to make certain that all the joints have adhesive squeeze-out, applying more as required to seal the joints airtight. When the adhesive has set, true to flush the exterior edges with a sander or router, rounding over the edges as may be required for any protective hardware.

If you're painting the cabinet, fill the holes over the nail or screw heads before

sanding and finishing the box. I prefer polyester auto-body filler for this job, because it sets fast, holds tight, and doesn't shrink. If you're carpeting the box, filling the heads is optional.

Put the access cover in place and drill eight to ten pilot holes for mounting screws or bolts/T-nuts through it and the flanges. Apply your finish of choice. DuraTex, available from www.AcryTech.com, is what the pros use. This water-base urethane acrylic goes on with a roller or hopper gun, drying quickly with a textured finish that's very durable and it's easily recoated if you ding it. It costs slightly more than paint, coverage is quite good, and you can finish a cabinet of this size in about 15 minutes exclusive of drying time.

TESTING

Install and wire the driver and jacks. Connect the +, - lugs of the driver to the +, - lugs of the Speakon jacks. Seal around the jacks with hot-melt glue or caulk (**Photo 5**). Rim the porthole flanges with weather-strip and screw the porthole cover in place. The rear chamber is not lined or filled.

Test the cab, using a 30Hz test tone from a generator or CD. Gradually increase power, listening for air leaks, which will seriously detract from performance, so be sure every joint is tight.

When using multiple cabs it's critical that they be wired in phase. To check phase run a test tone, anywhere from 30 to 100Hz, through one cab, then plug the second cab into the first. The level should go up. If the level goes down, you've either got the driver or jacks reverse-wired in one of the cabs, or the cable connecting the two cabs is reverse-wired at one end.

The key to high output isn't high power handling, it's high sensitivity, which increases as more cabs are added to the pile. **Figure 14** shows the responses of one, two, four, and eight S2010 loaded 16" cabs with 2.83V input. For even higher sensitivity, make the cabinet wider, with panel widths up to 26". **Figure 15** compares 16 and 24" wide S2010 loaded T24IIs. When building with 18" and wider panels, use two sets of braces, evenly spaced.

With nominal cabinet widths of 24 to 30", you can use two drivers for increased



PHOTO 4: Temporary braces keep panels squared.



PHOTO 5: Speakon jacks.

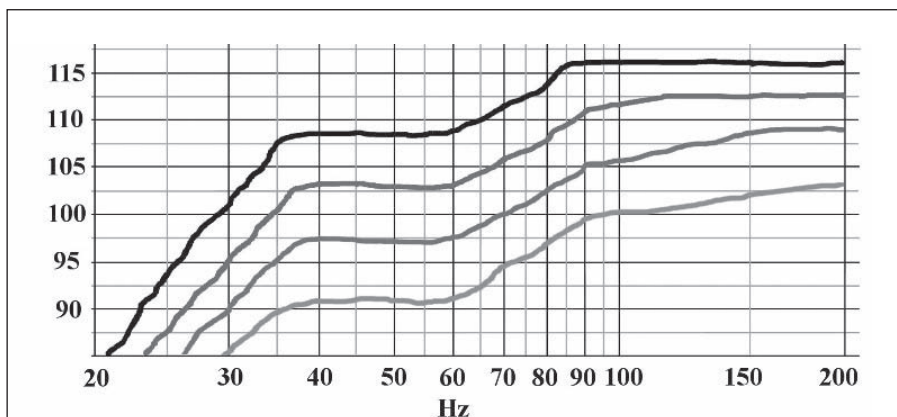


FIGURE 14: One, two, four, and eight cabs.

power handling. **Figure 16** shows a 24" cab loaded with dual S2010 drivers, parallel wired. Don't bother going wider than 30"; it's more practical to use two smaller cabs with one driver each. Dual drivers require a brace installed between panels 1 and 5, midway across the box.

You can achieve even higher sensitivity with the use of a "V" coupling. Stack the cabs in pairs at a 90° angle (**Fig. 17**). Then actively couple their mouths (**Fig. 18**) with a plate (**Fig. 19**) that extends the effective horn path. Attach the plate to the cabs via thumbscrews and T-nuts. The result, shown in **Fig. 20**, is an average sensitivity increase of 2.5dB, which is almost the equivalent of a doubling of power.

With more than two cabs, add ad-



PHOTO 6: Latching cabs together.



PHOTO 7: Two cabs latched for transport, front view.

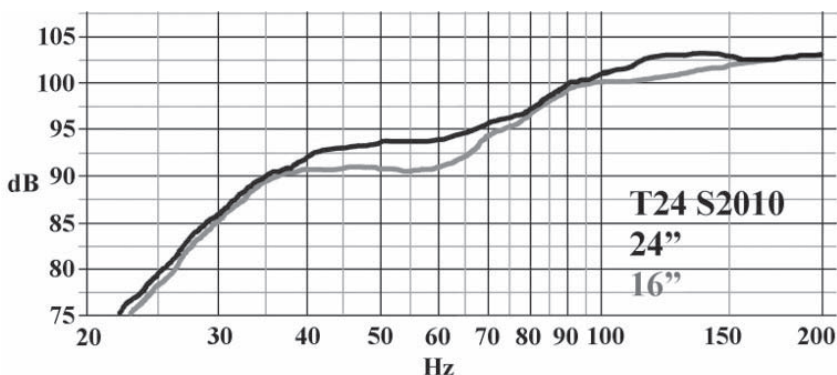


FIGURE 15: 16 and 24" wide cabs.

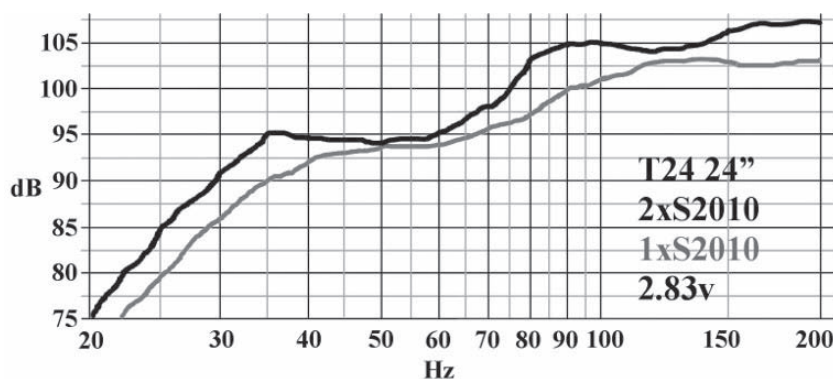
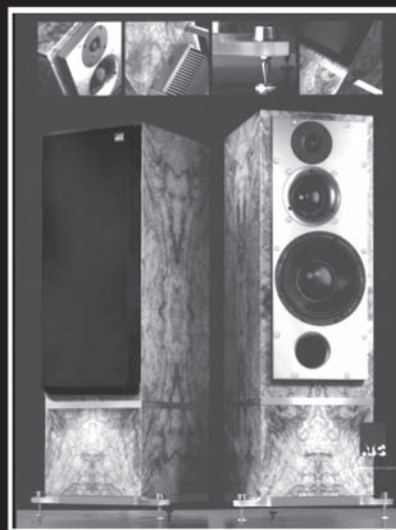


FIGURE 16: One vs. two drivers.



*Accurate
Precise
Musical
Revealing
Dynamic
Powerful
Durable
Beautiful*

ATC ACTIVE...NO COMPROMISES.

FLAT
EARTH
AUDIO IMPORTERS

U.S. Importers of
ATC, MANA & SME. | 888-653-5454
flatearthaudio.com

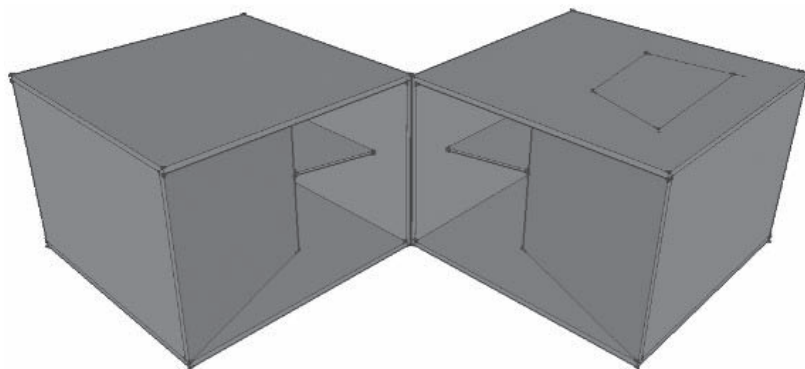


FIGURE 17: Two cabs arrayed.

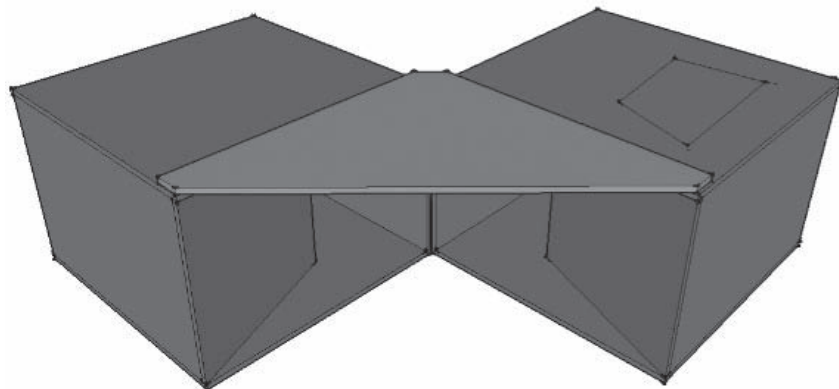


FIGURE 18: Two cabs arrayed with V coupler.



PHOTO 8: Two cabs latched for transport, rear view.

ditional pairs above the first, with just a single V plate at the top of the stack. For ease of transporting pairs of T24IIs, you can clamp them together with Penn-Elcom # LO925 clamps (**Photo 6**). Two extra holes in a V plate allow you to thumb-screw it to the existing T-nuts on assembly for transport (**Photo 7**). With wheels on both the top and bottom in transport mode, you can wheel the assembly to a van or station wagon, then tip it to place the upper wheels in the vehicle for an easy roll-in load-up.

SETUP TIPS

Figure 21 shows the impedance of an S2010 driver in a 16" wide T24. The air mass of the horn adds approximately 2Ω of acoustic impedance to the driver's nominal 8Ω impedance, resulting in a nominal 10Ω load. Two cabs parallel-wired will show a 5Ω load; four cabs will produce a 2.5Ω load. A dual driver cab parallel-wired will have a 5Ω load; two dual driver cabs will give a 2.5Ω load.

A dual driver cab series-wired will have an 18Ω load. Two such cabs will be 9Ω , four cabs 4.5Ω . Do not use a total load less than what your amp is rated to drive.

While it's customary with PA to have speakers to either side of the stage, that's usually not the best way to place subs. Subs work best when they're placed either close together for mutual coupling, or spread very wide to cover large areas. The basic rule is to have them either less than a quarter-wavelength apart or more than two wavelengths apart for their passband, which for 40 to 100Hz means less than 2.8' or more than 56'.

Use boundary loading whenever it's practical to do so. Having subs next to a wall gets you 6dB of additional sensitivity, while putting them in a corner an extra 12dB. In most cases you'll have best results aiming the subs toward the wall or corner with the mouth about a foot away from the boundary.

Horn-loaded subs have their own peculiarities, some of which led to this posting by Eminence regarding the Lab 12/Labsub; these caveats apply to Tubas as well:

You cannot hear the driver distort when you push them too hard. So, most people do not know when to turn them down. They

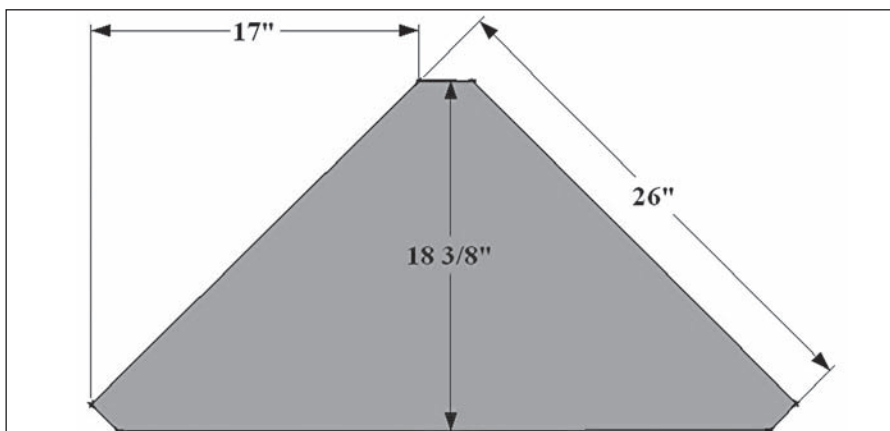


FIGURE 19: V coupler detail.

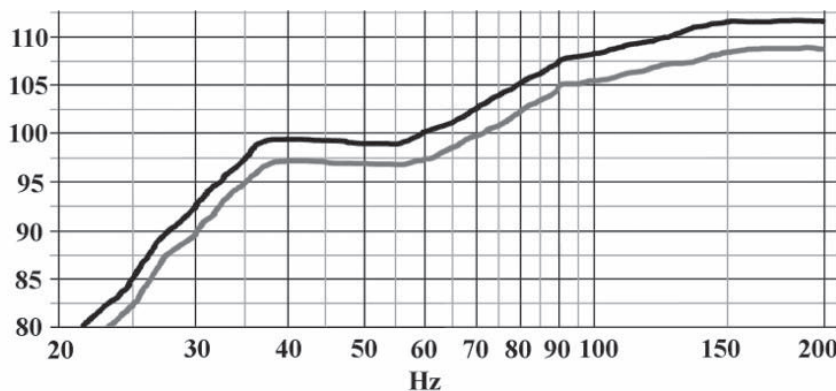


FIGURE 20: Two cabs with and without V coupler.

push them till they break. It takes a while to get used to the extra clean sound of this cabinet and learn how hard you can push it.

These are designed to be used in groups of 4 to 6 cabinets to get the desired SPL at very low frequencies (below 45Hz). A lot of folks are running them as singles and trying to EQ the bottom end to get more low bass output. This pushes the drivers past their safe operating range very quickly. If you need a lot of very low bass, use more cabinets.

Air leaks will kill the driver. Care must be taken to get the chamber sealed and keep it sealed. Before every show, check all the screws that keep the cover on as they may work loose and cause a leak.

You must use a high-pass filter set to 35Hz and that has a slope of at least 24dB per octave to realize the real potential of the design. Many people are using huge power on these cabinets day in and day out, but they are the ones who run steep high-pass filters on them. **ax**

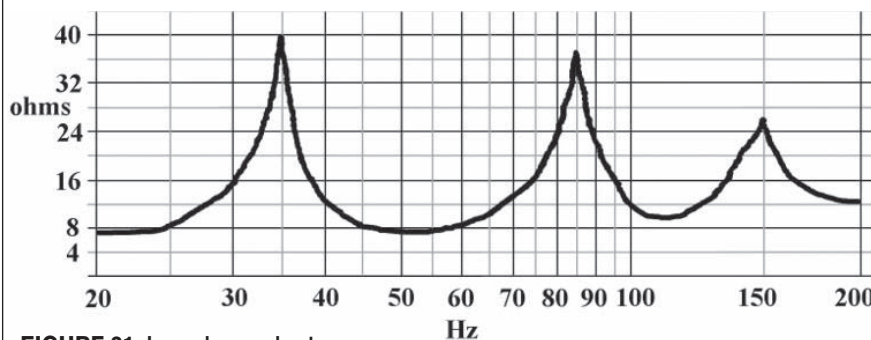


FIGURE 21: Impedance chart.

BK-16 Kit

Madisound is pleased to offer the **BK-16** folded horn kit.



F O S T E X

We have chosen the **Fostex FF165K** 6.5" full range for use in the BK-16 cabinet. The **FF165K** has a **Kenaf fiber cone**, inverted foam surround and aluminum dust cap.

The **FF165K** is run full range with a frequency response out to 15kHz. The **T90A** super tweeter has been added to cover the upper frequencies. The **T90A** is a top-mount horn tweeter with an **Alnico magnet**.

The tweeter is rolled off on the low end with a **Fostex Tin & Copper foil capacitor**. The system frequency response is 55Hz to 35kHz at 95dB.



The **BK-16** cabinet is made from **Baltic Birch** plywood and is sold flat, unassembled, unsanded and unfinished. Cabinet dimensions are 9.75" W x 14.75" D x 29" T.

The kit includes:

- Pair of Cabinets - Flat
- Pair of FF165K - full range
- Pair of T90A - horn tweeter
- Pair of DB-Cup - Input cup
- Pair of Crossovers
- Nordost 2-Flat wire for tweeter
- Instructions

Kit Price: \$635.00 /pair

Parts without cabinets: \$439.00 /pair

Cabinets only: \$98.00 each

MADISOUND SPEAKER COMPONENTS, INC.
 8608 UNIVERSITY GREEN
 P.O. BOX 44283
 MADISON, WI 53744-4283 U.S.A.
 TEL: 608-831-3433 FAX: 608-831-3771
 e-mail: info@madisound.com
 Web Page: <http://www.madisound.com>