

E P I Q U E

by Dayton Audio

D. B. Keele Jr.
Signature Series

CBT36K Assembly Manual

Constant Beamwidth Transducer System

PREFACE:

This is the assembly/instruction manual for the CBT36K, a DIY kit-version of the CBT36 system, a floor-standing CBT circular-arc high-end loudspeaker line array. The system is sold as a do-it-yourself (DIY) loudspeaker kit by Dayton Audio. The system is also available as a completed unit. The CBT36 is a floor-standing 5 ft. tall two-way curved line array that provides sonic accuracy, low distortion, and sound field coverage control surpassing even the finest high-end loudspeakers.

One additional amazing feature of the CBT36 is that it is time aligned and linear phase not only at a “magic listening spot” in front of the array but at locations on the floor, to locations above the array, and locations at extreme off-axis horizontal angles!

The CBT36 is based upon declassified military research on uniform-coverage underwater sound transducers originated by the US Navy in the late 70s and early 80s. CBT, which stands for **C**onstant **B**eamwidth **T**ransducer, is a term coined by the military researchers in their technical papers. The system is designed by Marshall Kay and Don Keele.

Each array features 18 Dayton Audio 3.5" ND Series drivers along with 72 specially designed 1/2" aluminum dome tweeters, and is available in kit form as well as a fully assembled product. The CBT36 will redefine your expectations of audio reproduction system performance!

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1. THE PRELIMINARIES:

INTRODUCING the CBT36:



The CBT36 is a floor-standing 5ft.-tall two-way curved line array that provides sonic accuracy and sound-field coverage that surpasses even the finest high-end loudspeakers.

The system not only provides extremely even coverage at all points up-down, right-left, and near-far; but is linear-phase and time-aligned at all these points also!

Based upon declassified military research on Constant Beamwidth Transducers (CBT) originated by the U.S. Navy, and a series of technical papers by Don Keele, the system was designed by Marshall Kay and Don Keele.

Each array features 18 Dayton Audio 3.5" ND Series drivers with 72 specially designed 1/2" aluminum-dome tweeters, and is available assembled or in kit form. The CBT36 will redefine your expectations of audio reproduction system performance.

1.1. OVERVIEW OF THIS MANUAL AND THE ASSEMBLY PROCESS:

This manual describes the assembly process of the CBT36K curved-arc high-end loudspeaker array sold by electronic supplier Parts Express. It includes many sections to aid in the assembly procedure. Two appendices are provided at the end of this manual: the first gives a detailed description of the CBT36 along with a set of specifications, and the second fully describes the theory of operation behind CBT loudspeaker arrays and how it applies to the design of the CBT36 and includes a CBT bibliography.

When you first view this manual for the CBT36K, the assembly process looks very imposing, complicated and difficult! But first looks can be deceiving. We have done all we can to simplify the assembly process by spelling out the procedure in great detail and documenting all steps with high-resolution photos to guide you through the process.

Although the manual is quite large, it's jam-packed with useful information. With the comprehensive information provided in this manual, the CBT36 has to be the most documented high-end loudspeaker that has ever been sold! There are absolutely no secrets here!

This manual contains many sections and subsections which take you through the assembly process in much detail. A master check list is provided along with check boxes in the individual sections of the manual.

1.1.1. What Parts are Supplied?

Here is a quick peek at what we supply: 1. Complete cabinet (unfinished), 2. Front panel (unfinished), 3. All loudspeakers including 36 mid-bass drivers and 144 tweeters (organized into 36 four-tweeter PC board modules), 4. All resistors, 5. All required screws, fasteners and brackets, 6. All gaskets and sealing caulk, 7. Two Speakon connectors, 8. Seven spools of multicolored stranded wire, 9. Wire nuts, 10. Rosin core solder, and 10. A bag of Acousta-Stuf Polyfill absorption material, etc.

These parts are listed and described in the “Material Inventory List” section later in this manual.

1.1.2. What Parts Aren’t Supplied?

Here is a brief list of what we don’t supply: 1. The DSP loudspeaker crossover/EQ, 2. Small tools and supplies including: wire stripper/cutter, pliers, screw drivers, hex wrenches, batteries, razor blades, and rulers, etc., 3. Large tools including: soldering station, hot-glue gun, and motorized screwdriver, etc., 4. Consumables: paint, primer, polishing compounds, electrical tape, sand paper, glue, and RTV Silicone adhesive, etc., and 5. Audio test tools including: microphone, power amplifier, digital multi-meter (DMM) or AC voltmeter, audio signal generators, and cabling and connectors.

A more detailed list of all the required tools and consumables is listed later in the section “TOOLS AND CONSUMABLES NEEDED.”

1.1.3. What’s Ahead in the Assembly of the CBT36K?

The construction of the CBT kit consists of 15 main steps:

- 1) Inventory of all the supplied parts.
- 2) Preparing the work space.
- 3) Gathering all required tools and consumables
- 4) Gathering all gear required for speaker testing including: DMM/AC voltmeter, test microphone, audio generator, amplifiers, and cables.
- 5) Sanding and finishing the cabinet.
- 6) Test all drivers.
- 7) Prepare the resistors.
- 8) Prepare the connecting wires.
- 9) Mount mid-bass drivers and tweeter PC board modules to front panel.
- 10) Wire mid-bass drivers and tweeter PC board modules.
- 11) Test polarity and shading network attenuations.
- 12) Connect drivers to rear panel connector.
- 13) Install gasket material and acoustic stuffing in the cabinet.
- 14) Mount front panel with drivers to the cabinet.
- 15) Wrap up including buzz and rattle tests.

1.1.4. How Long will it Take to Assemble the Kit?

Steps 5, 8, and 14 will take the most time. By far, the most time consuming and demanding step is number 5 “Finishing the cabinet.” The cabinet finish can range from something as simple as spray painting it flat black to applying a fine automotive high-gloss metallic finish (like the red automotive metallic finish of the featured demo units). Sanding and drying time between coats must also be included.

Here are the estimated times for steps 5 to 15 rounded up to the nearest half hour. Depending on your skill level, *your times may vary significantly* from these estimated completion times.

Estimated Assembly Time Table (Total Time: 17 Hours, not counting finishing!)

5) 24.0+ Hr, Sanding and finishing the cabinet.	11) 2.0 Hr, Test polarity and shading network attenuations.
6) 1.0 Hr, Test all drivers.	12) 1.0 Hr, Connect drivers to rear panel connector.
7) 1.0 Hr, Prepare the resistors.	13) 2.0 Hr, Install gasket material and acoustic stuffing in the cabinet.
8) 3.0 Hr, Prepare the connecting wires.	14) 3.0 Hr, Mount front panel with drivers to the cabinet.
9) 1.0 Hr, Mount mid-bass drivers and tweeter PC board modules to front panel.	15) 2.0 Hr, Wrap up including buzz and rattle tests.
10) 1.0 Hr, Wire mid-bass drivers and tweeter PC board modules.	

1.2. MASTER CHECKLIST:

To make sure you assemble the right and left stereo pairs of CBT36 cabinets in the correct sequence, the following master check list must be followed. Each of the steps in this checklist may require several intermediate steps. This list will also be provided separately as a handout.

Please watch the on-line assembly video before you do any of the following tasks. It will give you a good overview of the assembly of the CBT36.

- | | LEFT | RIGHT | |
|-----|--------------------------|--------------------------|---|
| 1. | ☐ | ☐ | Un-box all components (two boxes for the cabinet kits and one box for parts). |
| 2. | ☐ | ☐ | Inventory items received against the CBT36K Material List. |
| 3. | ☐ | ☐ | Test ND91 Mid-bass drivers and Tweeter modules (Contact Parts Express to report failures and request possible replacements). |
| 4. | ☐ | ☐ | Apply desired finish to all cabinet parts. |
| 5. | ☐ | ☐ | Prepare resistors |
| 6. | ☐ | ☐ | Cut and prepare all wire lengths. |
| 7. | ☐ | ☐ | Load tweeter modules in front panels. |
| 8. | ☐ | ☐ | Load mid-bass ND91 drivers in front panels. |
| 9. | ☐ | ☐ | Dry wire (do not solder) all connections for both panels. <i>Soldering is not done at this point in the assembly process because it is much easier to correct wiring errors if the connections are not soldered. Soldering will only take place after the wiring is verified correct.</i> |
| 10. | ☐ | ☐ | Carefully compare your wiring with the front-panel foldout, correct any errors, and then solder. |
| 11. | ☐ | ☐ | Glue resistors and dress wiring, apply a drop of finger nail polish to each screw. |
| 12. | ☐ | ☐ | Test driver polarities. |
| 13. | ☐ | ☐ | Test shading bank attenuations. |
| 14. | ☐ | ☐ | Final assembly. |
| 15. | ☐ | ☐ | Setup external active Crossover. |
| 16. | ☐ | ☐ | Setup the remaining part of the system including line level connections and speaker cable connections to power amps. |
| 17. | ☐ | ☐ | Power up for the first time and make sure it works. |
| 18. | ☐ | | DONE! Whew! Enjoy! |

1.3. WORK AREA:

Find a comfortable well-lit place to assemble your kit. You will need a 6 ft or longer table adjusted to the proper height depending on if you prefer to work standing up or sitting down. It is a good idea to cover the surface in a soft carpet to prevent scratching the painted parts. You will need access to A/C power for soldering irons and glue guns. Refer to Figs 1 and 2 at the start of this manual for illustrations of the work area for the CBT36 prototypes.

1.4. SAFETY FIRST:

During the process of assembly you will be using tools and chemicals that could be harmful to your health. Wear appropriate eye protection, respirators and protective gloves during the sanding and painting steps and always work in an area that has plenty of ventilation and lighting. Eye protection is very important when trimming leads and wires and make sure the area is well ventilated during soldering. Soldering irons can reach very high temperatures (800 degrees) and soldering iron burns are very painful and most importantly soldering irons can cause fire if left unattended so **NEVER LEAVE A SOLDERING IRON UNATTENDED**. Always think safety first.

2. WHAT'S NEEDED?

2.1. TOOLS AND CONSUMABLES NEEDED:

In addition to the items supplied with the kit you will need some basic tools and consumables to complete your CBT36 kit. Refer to the lists below and the following photos for a quick overview of the required tools and consumables (**NOTE:** Painting supplies are shown in the cabinet finishing section of this manual).



Fig. 3. Tools and consumables required in the assembly of the CBT36. See the following two lists for individual items.

2.1.1. Tools:

- 1) Wire stripper
- 2) Wire cutters
- 3) Needle nose pliers
- 4) 4mm or 5/32 Allen (Hex) tool
- 5) #2 Phillips screw driver
- 6) Ratchet with adapter for a Phillips screw driver
- 7) Sharpie felt tip pen
- 8) Yard or meter measuring stick
- 9) Soldering Iron
- 10) Hot glue gun and glue sticks
- 11) Test leads
- 12) 1.5v and two - 9v batteries
- 13) Single-edge razor blades or Exacto knife and blades

2.1.2. Consumables:

- 1) Sand paper grits 150, 180, 220, 320, 400
- 2) Primer
- 3) Paint
- 4) Polishing compounds (for automotive finishes)
- 5) Thin (not a GEL) Super Glue
- 6) RTV silicone adhesive (not shown)
- 7) Can of compressed air or air hose with nozzle connected to a compressor
- 8) Finger nail polish (your favorite color)
- 9) Electrical tape (not shown)

2.2. AUDIO MEASUREMENT TOOLS:

The following software tools, equipment, and supplies will help in the measurement and testing of the CBT36 arrays.

2.2.1. Stand-Alone Generators:

It would help if you have on hand an audio generator or function generator such as the following (listed without descriptions and lifted from Google Images. You old timers may remember some of these generators!):

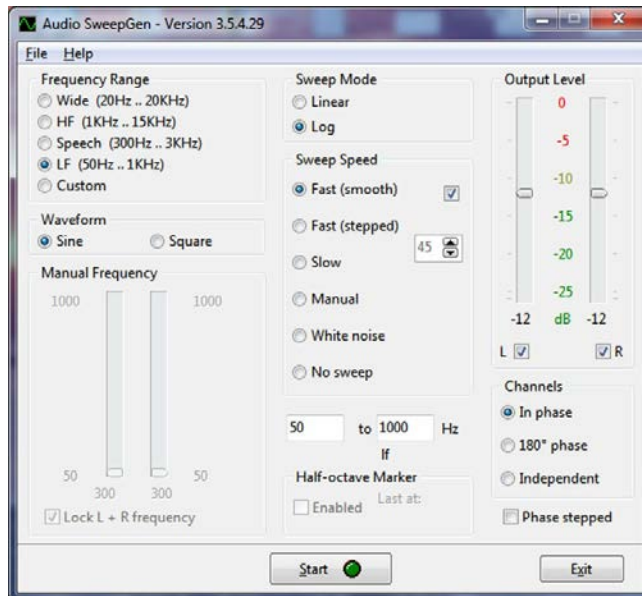


2.2.2. Signal Generator Free-Software Options:

2.2.2.1. David Taylor Audio SweepGen Signal Generator:

<http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=17725>

This generator is free on the Internet and is easy to use. It will generate continuous sine/square signals plus log/linear stepped/continuous sweeps from arbitrary start-stop frequencies.



2.2.3. Speaker Connector Cable and Wiring Options:

2.2.3.1. Do-it-Yourself Speaker Cable:

<http://www.parts-express.com/neutrik-nl4fc-speakon-connector-4-pole-cable-mount--092-050>

If you wish to construct your own test cable or your own a pair of speaker cables, order two of the Neutrik Speakon NL4FC four-wire speaker connectors for the CBT36 connection and the appropriate four-conductor 16 AWG or larger cable and connectors to mate with your power amplifier.



2.2.3.2. Speakon Connector Wiring and Documentation:

<http://www.n4tze.com/speakonconnectorwiring.pdf>

This document will help explain the Speakon NLF4C connector and its wiring.

2.2.4. Test Power Amplifiers with Volume Control:

The following two Dayton Audio power amplifiers, available from Parts Express, are good quality, relative inexpensive, and have a power rating of ten watts or greater:



2.2.4.1. Dayton Audio DTA-120 Class T Mini Amplifier 60 WPC:

<http://www.parts-express.com/dayton-audio-dta-120-class-t-mini-amplifier-60-wpc--300-3800>

2.2.4.2. Dayton Audio APA150 150W Power Amplifier:

<http://www.parts-express.com/dayton-audio-apa150-150w-power-amplifier--300-812>

2.2.5. Digital Multi-meter:

2.2.5.1. Triplet 1101-B Compact DMM with Backlit Display:

<http://www.parts-express.com/triplett-1101-b-compact-dmm-with-backlit-display--391-062>

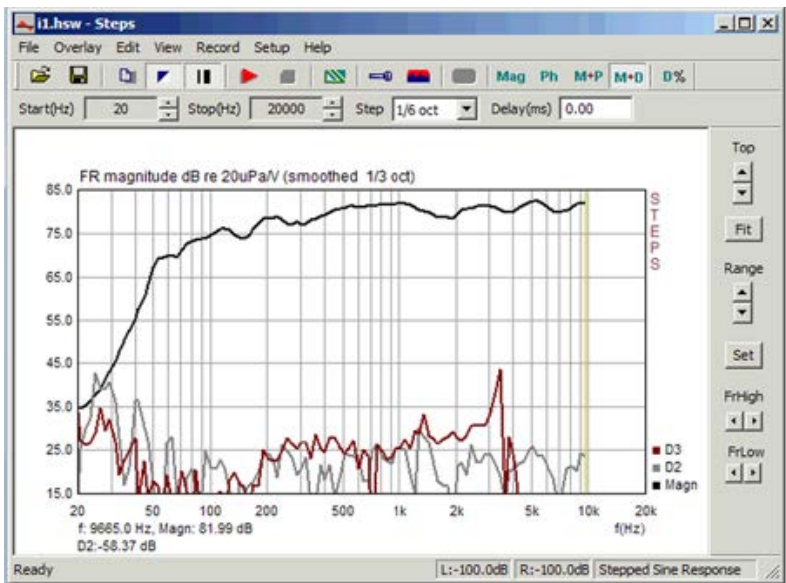


2.2.6. Analyzer Options:

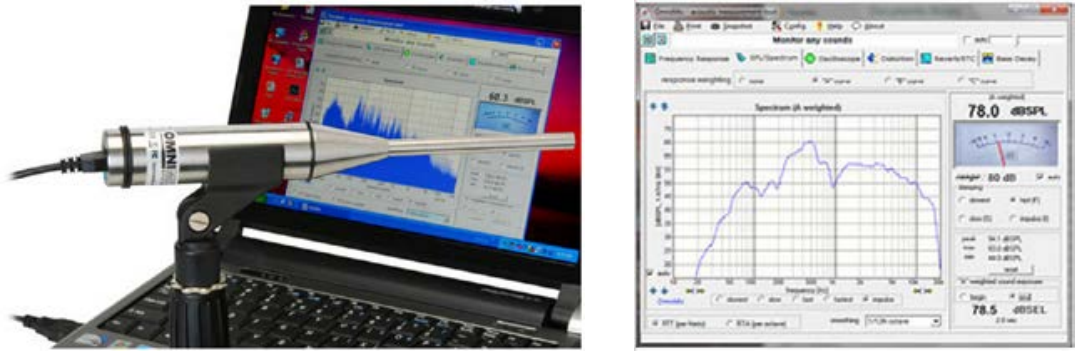
These are optional advanced measurement tools.

2.2.6.1. ARTA Audio Measurement and Analysis Software:

<http://www.fesb.hr/~mateljan/arta/>



2.2.6.2. Dayton Audio OmniMic V2 Precision Measurement System:
<http://www.parts-express.com/dayton-audio-omnimic-v2-computer-based-precision-room-measurement-system--390-792>
This is the Dayton Audio OmniMic V2 System, a USB microphone and analysis software combination.



2.2.6.3. Dayton Audio DATS V2 Computer Based Audio Component Test System:
<http://www.parts-express.com/dayton-audio-dats-v2-computer-based-audio-component-test-system--390-806>



2.2.7. Measurement Microphone Options:
These are optional advanced measurement tools.

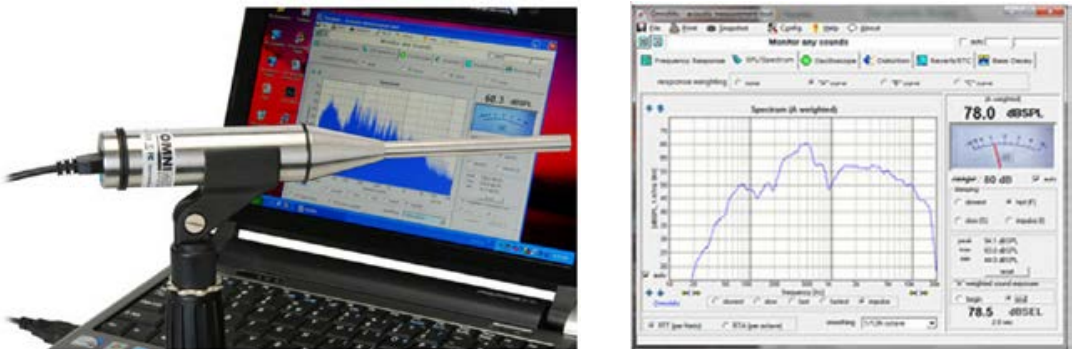
2.2.7.1. Behringer ECM8000 Measurement Microphone:
<http://www.parts-express.com/behringer-ecm8000-measurement-microphone--248-625>



2.2.7.2. Dayton Audio EMM-6 Electret Measurement Microphone:
<http://www.parts-express.com/dayton-audio-emm-6-electret-measurement-microphone--390-801>



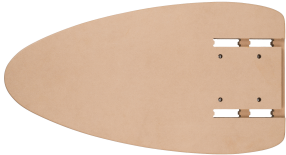
2.2.7.3. Dayton Audio OmniMic V2 Precision Measurement System:
<http://www.parts-express.com/dayton-audio-omnimic-v2-computer-based-precision-room-measurement-system--390-792>
This is the Dayton Audio OmniMic V2 System, a USB microphone and analysis software combination.



3. WHAT'S HERE?

3.1. MATERIAL INVENTORY LIST:

3.1.2. Material List in Detail:

ITEM	QTY	DESCRIPTION:	IMAGE:
1	2	3.1.2.1. MDF Cabinet Kit: Make sure you identify left and right cabinets. To do this, locate the holes at the bottom of each cabinet and position those next to each other and verify that the tweeter holes are next to one another.	
2	2	3.1.2.2. Cabinet Base:	
3	4	3.1.2.4. Base Mounting Bolts:	
4	40	3.1.2.6. Front-Panel Mounting Screws: 1-1/2 inch x 1/4-20 round Allen head screws. These screws attach the front panel to the enclosure (20 per enclosure). NOTE: These screws are not supplied separately. They come with the un-finished cabinet assembly and attach the front panel to the cabinet. The front panel will be removed when the assembly process is started and they must be saved for later reuse.	
5	292	3.1.2.7. Mid-Bass Driver and Tweeter Module Mounting Screws: Two bags each containing 146 each 6-32 x 5/16 screws. These screws attach the mid-bass drivers and tweeter modules to the inside of the front panel.	
6	4	3.1.2.9. Neutrik Speakon NL4MP Connector Screws: One bag containing four #4 x 5/8" flat head Phillips wood screws.	

7	1	3.1.2.10. Front Panel Gasket Material: One 36 ft roll of 1/2 inch wide x 1/16 inch thick Neoprene Sponge. 18 ft of this gasket material will be used per speaker.	
8	2	3.1.2.12. Sound Absorption/Dampening Fiber: Two One lb bags of Acousta-Stuf Polyfill absorption material. 	
9	3	3.1.2.13. Speaker Sealing Caulk: One 36 inch roll of 1/4 inch wide sealing caulk. This caulk is used for wire management on the back of the front panels. Strips are self-adhesive and stick easily to any surface it is pressed against.	
10	2	3.1.2.14. Four-wire Chassis-Mount Speaker Connector: Neutrik Speakon NL4MP. Each cabinet has one of these mounted on the bottom rear of the cabinet. The connector has four wires which allow the both the mid-woofers and the tweeters of the CBT36 to be connected with one connector. A good reference for Speakon connectors and wiring is found at: http://www.n4tze.com/speakonconnectorwiring.pdf.	
11	2	3.1.2.15. Resistor, Non-Inductive Wire-Wound, 1.0 Ohm: Mills brand, 12W, 1% Tolerance.	
12	10	3.1.2.16. Resistor, Non-Inductive Wire-Wound, 1.5 Ohm: Mills brand, 12W, 1% Tolerance. (NOTE: Image shows a 1.0 Ohm.)	
13	4	3.1.2.17. Resistor, Non-Inductive Wire-Wound, 2.0 Ohm: Mills brand, 12W, 1% Tolerance. (NOTE: Image shows a 1.0 Ohm.)	
14	2	3.1.2.18. Resistor, Non-Inductive Wire-Wound, 2.5 Ohm: Mills brand, 12W, 1% Tolerance. (NOTE: Image shows a 1.0 Ohm.)	
15	4	3.1.2.19. Resistor, Non-Inductive Wire-Wound, 3.0 Ohm: Mills brand, 12W, 1% Tolerance. (NOTE: Image shows a 1.0 Ohm.)	
16	4	3.1.2.20. Resistor, Non-Inductive Wire-Wound, 5.0 Ohm: Mills brand, 12W, 1% Tolerance. (NOTE: Image shows a 1.0 Ohm.)	

17	36	3.1.2.21. Tweeter Module Assembly: Four tweeters mounted on PC board, Dayton Audio model ND13TG-8. The 3/4" diameter wide-range tweeters are made by Dayton Audio, and feature a 0.5" edge-drive inverted aluminum dome that utilizes a high-energy neodymium magnet for low distortion and high efficiency. The tweeters are mounted on PC boards in groups of four to ease assembly and optimize center to center spacing. The center-to-center spacing of the tweeters is 22.7 mm (0.892").	
18	36	3.1.2.22. Mid-Bass Driver: Dayton Audio ND91-8, 3-1/2" Aluminum Cone Full-Range Driver 8 Ohm: http://www.parts-express.com/pe/showdetl.cfm?Partnumber=290-226	
19	36	3.1.2.23. Mid-Bass Driver Gasket: Dayton Audio part which may be packed in the mid-bass driver box.	
20	1	3.1.2.24. Hook-Up Wire, 18 AWG, RED: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For ND91 Mid-Bass wiring.	
21	1	3.1.2.25. Hook-Up Wire, 18 AWG, BLACK: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For ND91 Mid-Bass wiring.	
22	1	3.1.2.26. Hook-Up Wire, 18 AWG, GREY: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For ND91 Mid-Bass wiring.	
23	1	3.1.2.27. Hook-Up Wire, 18 AWG, YELLOW: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For ND91 Mid-Bass wiring.	

24	1	3.1.2.28. Hook-Up Wire, 24 AWG, BLACK: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For tweeter wiring.	
25	1	3.1.2.29. Hook-Up Wire, 24 AWG, RED: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For tweeter wiring.	
26	1	3.1.2.30. Hook-Up Wire, 24 AWG, YELLOW: Stranded, 25 ft. spool, tinned copper conductor, Consolidated brand. For tweeter wiring.	
27	1	3.1.2.31. Solder, 60/40 Rosin Core: Diameter 0.031", 0.50 oz. tube, 15 ft., Kester brand Pocket Pack.	
28	10	3.1.2.32. Wire Nuts: NTE twist on wire connector (22-14) AWG grey with spring insert.	

4. CABINET FINISHING:

4.1. FINISHING THE CABINET:

The CBT36 front panel is finished separately from the rest of the cabinet components. As noted below, the front panel is finished with an acrylic automotive finish while the rest of the cabinet is finished in a low-luster black lacquer. The following steps describe the finishing of both sections of the cabinet.

4.1.1. ☐ Gather All Items to be Painted:

Gather all the items that need to be painted. Remove the front panel from the cabinet by removing all (20) of the 1/4-20 x 1.5 inch machine screws using the Allen tool specified above and set it aside for the moment. If you are new to finishing, it is best to finish your kit in groups. For instance, start with the top caps and bases because these are smaller parts that will give you practice before you start work on the main cabinet.

4.2. ☐ SELECT PAINTING SYSTEM:

You must select a painting system and color for your cabinets. Consult your painting supply vendor for options. All cabinet components except for the front panel of the original CBT36 are painted with a low-luster black pre-catalyzed lacquer. The front is painted with a metal-flake acrylic automotive finish.



Fig. 4. CBT36 cabinet showing front panel being unscrewed.

4.3. CABINET FINISHING:

4.3.1. ☐ Cabinet Sanding:

MDF parts are sanded after they come off the CNC machine and assembly area, so most of the work is already done for you. However to achieve a high end finish you will need to sand and prime the parts. We recommend that you start with 150 grit sand paper to sand the edges, this will remove remaining tool marks. Next move to 180 grit and continue sanding the edges and finally use the 220 grit sand paper.

4.3.2. ☐ Prime the Cabinet Surface:

Apply a heavy solids primer compatible with the paint system you have chosen, if you spray the primer on, you will need to consult the paint vendor for recommendations on tip diameter and air pressures. Allow the primer to cure for the specified time prior to sanding. Start with 220 grit and sand all surfaces lightly, but pay particular attention to the edges. Step up to 320 grit paper and again sand all surfaces lightly and finally move to 400 grit and again sand all surfaces. If you wish, you can continue to 600 grit sand paper as the last sanding step.

4.3.3. ☐ Cabinet Painting:

Apply a minimum of three coats of paint to the cabinet. A light texture looks good on the CBT36 cabinet and is easily achieved by lowering the air pressure on the spray gun so the droplets of paint become larger. After the last coat dries, you can give the cabinet a textured look by lightly misting the cabinet with paint under low air pressure. You should practice this on some scrap material to make sure you get the hang of it prior to spraying your cabinets.

4.4. ☐ FRONT PANEL FINISHING:

The front-panel color of the systems shown at the start of this manual and in the Parts-Express catalog is General Motors Paint Code: 3986 called medium garnet red. See Ditzler PPG:

<http://paintref.com/cgi-bin/paintdetail.cgi?ppg=3986>,
<http://paintref.com/cgi-bin/colorcodedisplay.cgi?ditzler=3986>,
and <http://www.ppg.com/coatings/autooem/about/Pages/History.aspx>.

The following figure shows an example of these front-panel finishing consumables.

(See <http://www.ppg.com/coatings/refinish/en/products/omni/Pages/default.aspx>, also <http://www.growautomotive.com/high-efficiency-solvents.php>).



Fig. 6. Consumables for finishing the front panel of the CBT36 cabinet.

Finishing the front panels follows the same steps as above for the cabinet but you need to be very careful working around the tweeter holes. The MDF is machined to 30 thousandths thickness and can be damaged by aggressive sanding. The bevels where the mid-bass drivers mount require the most attention. Sand through all the steps as described above and you may want to brush on a coat of primer on these surfaces and repeat the pre-primer sanding process prior to spraying the entire front panel with primer.

The painting system applied to the CBT36 front panel starts with a heavy-solids primer, followed by two coats of the metallic base, followed by two coats of high gloss top coat. Allow the paint to cure the specified time between each coat. If you take your time and do a good job sanding the primer, you should not need to sand between the base coats. The top coat can be polished with automotive polishing compounds and a buffing wheel to give a metallic looking finish.

4.4.1. ☐ After Painting is Complete Start the Assembly:

Once painting is complete, the rest of the assembly process will move quickly. Just follow the Master Check List at the beginning of this manual and it will guide you through each section.

OK, it's time to start building this amazing new speaker!

5. TESTING AND PREPARATION OF WIRES, COMPONENTS, AND RESISTORS:

5.1. ☐ **TEST ALL MID-BASS DRIVERS AND TWEETER MODULES:**

These steps must be done first to insure that all the drivers are operating satisfactorily.

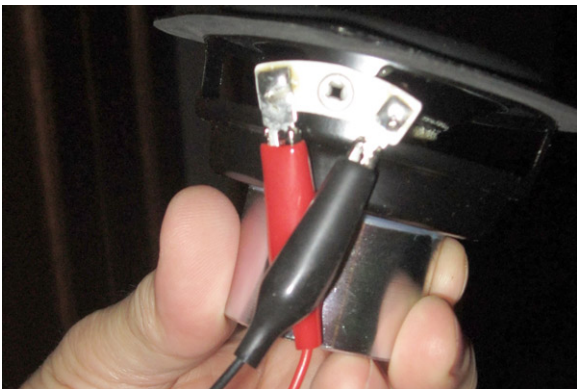
5.1.1. ☐ **Check the ND91 Drivers for Debris in the Voice Coil:**



Hold the driver close to your ear and press the center of the cone gently and listen for scraping noises. Good drivers are completely quiet!

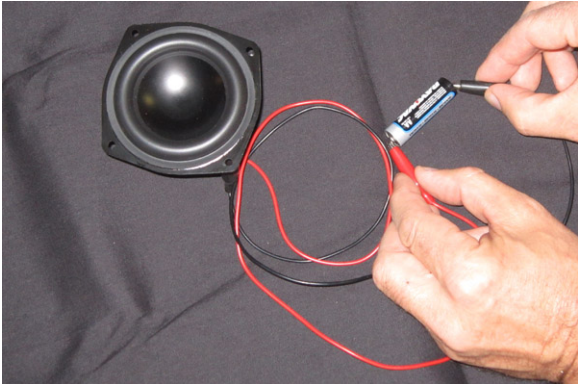
5.1.2. ☐ **Check ND91 Voice Coil Polarity:**

5.1.2.1. *Connect test leads:*



Connect test leads to the ND91. RED clip to the (+) terminal and BLACK clip to the (-) terminal.

5.1.2.2. *Connect the other ends of the test leads to a battery:*

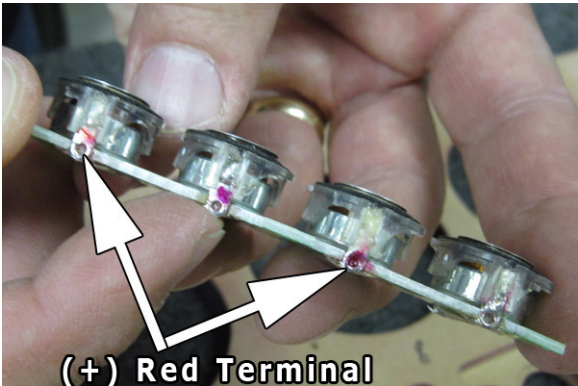


Hold the BLACK test lead to the (-) side of a 1.5v battery and tap the RED test lead on the (+) side of the battery. The cone should move out!

5.1.3. ☐ **Check Tweeter Module Voice Coil Polarity:**

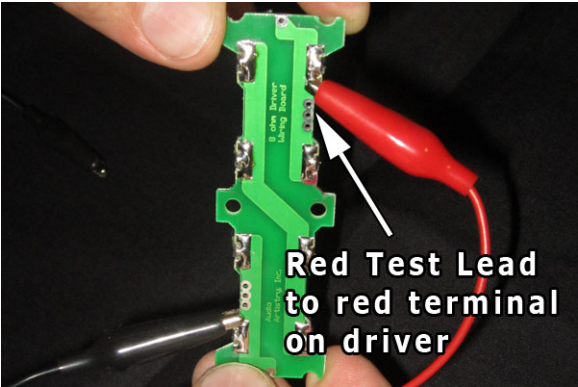
Here you will check the polarity of each of the tweeter modules (36 in all).

5.1.3.1. *Look for the Red Mark on the Positive Tweeter Terminal:*



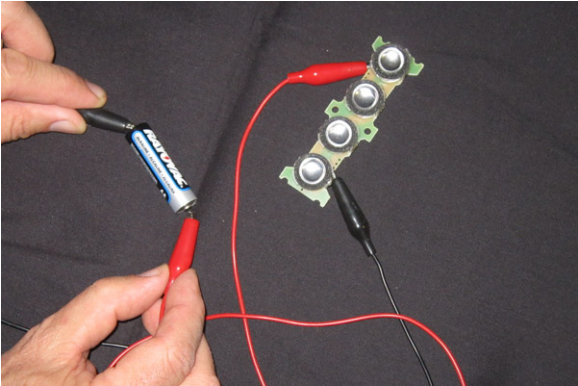
Locate the Red marks on the tweeter module.

5.1.3.2. **Connect the test leads to the tweeter module:**



Connect the test leads to the tweeter module as shown above. The RED test lead connects to the side with the RED mark on the driver (see next photo).

5.1.3.3. **Connect the other ends of the test leads to a battery:**



Hold the BLACK test lead to the (-) side of a 1.5v battery and tap the RED test lead on the (+) side of the battery. All cones should jump forward. If none move, double check your connections and the module itself.

5.1.4. ☐ **Check DC Resistance of ND91 Mid-Bass Voice Coil:**



Set the DMM to ohms and check the DC resistance of the voice coils for all 36 ND91s. The reading will be very close to eight Ohms. (For more accuracy in the measurement first short the test leads together before connecting the drivers and subtract that reading from the measurements for each driver). You may also use the Parts Express WT3 to measure the impedance. This reading is very sensitive to noise and vibration. Make this measurement in a quiet area.

5.1.5. ☐ **Check DC Resistance of Tweeter Modules:**

Following the same procedure as in the previous section, check the DC resistance of the tweeter modules. Connect your test leads to the same locations as the tweeter polarity test. The reading also should be quite close to eight Ohms.

5.2. ☐ **PREPARE THE RESISTORS:**
Overview:

Two sets of parallel resistors with different lead configurations are prepared in the following steps. The first parallel combination has straight leads coming from the resistor body:

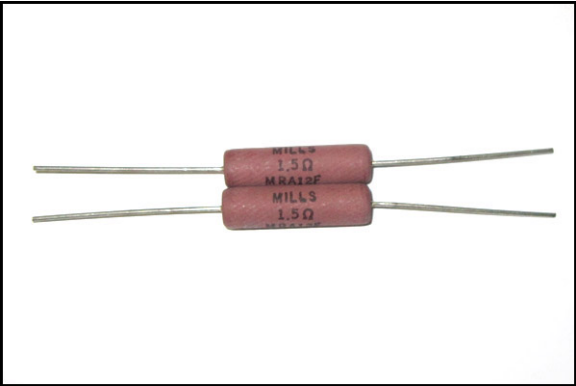


The second parallel combination has a 90° bend in the left lead:



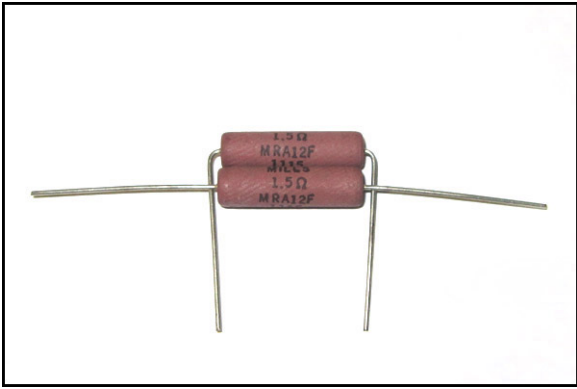
These parallel resistor combinations will be prepared in the following steps.

5.2.1. ☐ **Position Resistors:**



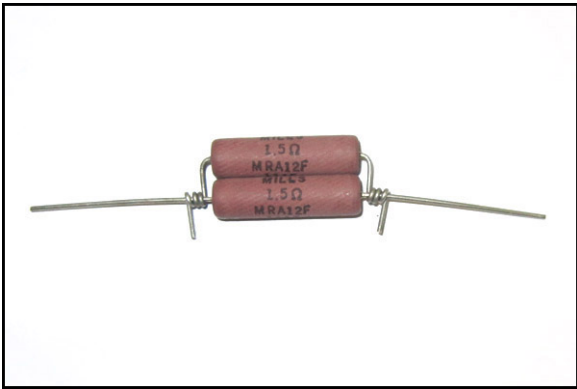
Position the resistors as shown (check the resistor configuration list, shown later in Section 5.2.5, to determine which resistors get connected this way).

5.2.2. ☐ Bend Resistor Leads:



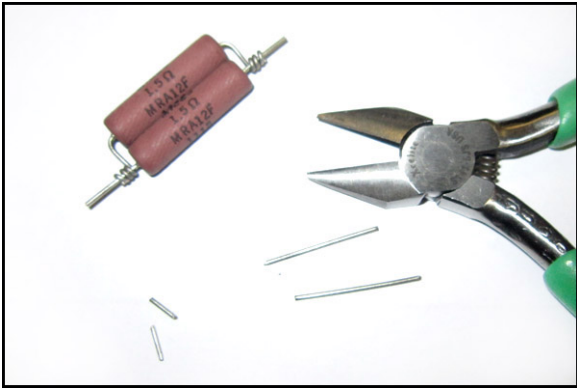
Bend the leads on one of the resistors as shown.

5.2.3. ☐ Wrap the Bent Leads:



Wrap the bent leads three times around the straight leads.

5.2.4. ☐ Trim Longer Leads:



Trim the longer leads to 1/2 inch and trim the twisted wire close to the long lead.

Save the longer cutoffs for later use. (20 will be needed later!)

5.2.5. ☐ Straight-Lead Parallel Resistor
Configurations:

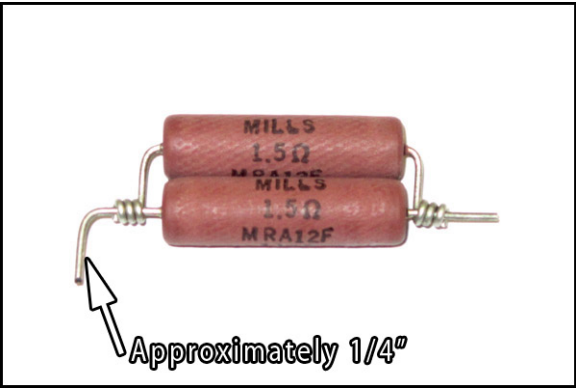
Prepare eights sets of straight-lead parallel resistor combinations following the previous photos (each set has two resistors in parallel), as follows:

- 1) 5 Ohm and 5 Ohm (two pairs)
- 2) 3 Ohm and 3 Ohm (two pairs)
- 3) 2 Ohm and 2 Ohm (two pairs)
- 4) 1.5 Ohm and 1.5 Ohm (two pairs)

5.2.6. ☐ Bent-Lead Parallel Resistor
Configurations This One is Different!

Configure two sets of parallel 1.5 Ohm resistors with a 90 deg bend on the left side as shown in the following photo. The part that bends downward should be about 1/4 of an inch long.

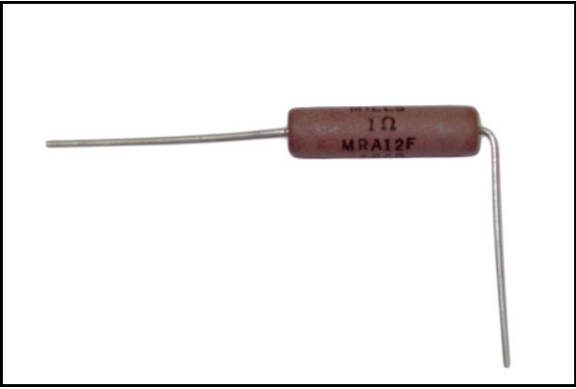
- 1) 1.5 Ohm and 1.5 Ohm (two pairs)



5.3. ☐ CONFIGURE AND TRIM THE
RESISTOR LEADS:

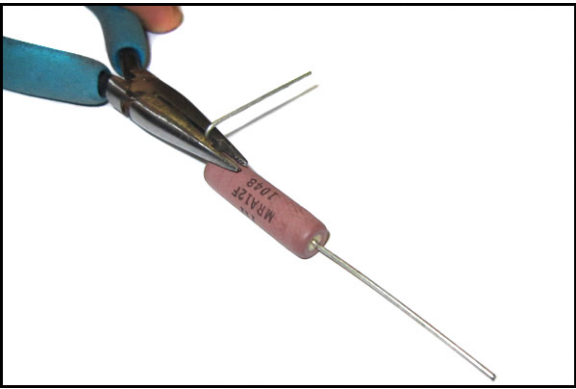
Configure and trim the leads as shown for two each of 1.0, 1.5 and 2.5 ohm resistors.

5.3.1. ☐ Bend Leads:



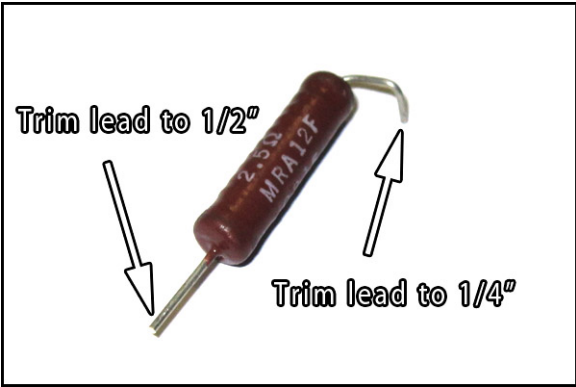
Bend the right lead 90 degrees after it exits from the resistor body.

5.3.2. ☐ Second Bend:



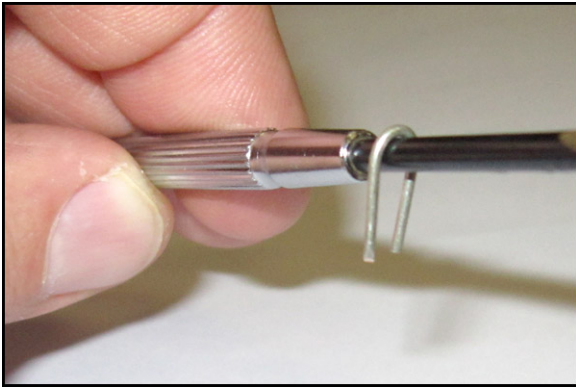
Hold the lead with needle nose pliers and make a second bend as shown.

5.3.3. ☐ Trim the Leads:



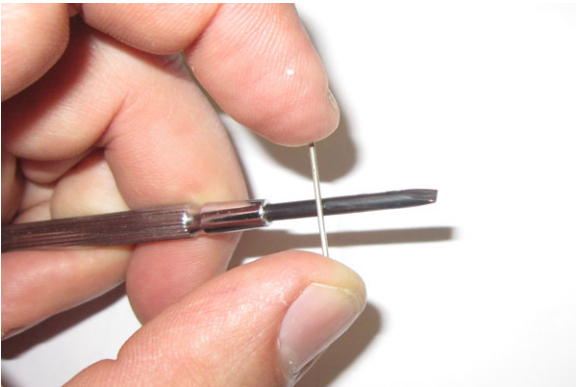
Trim the leads and save the cutoffs for use later.

5.3.5. ☐ Create U-Shape Cutoffs:



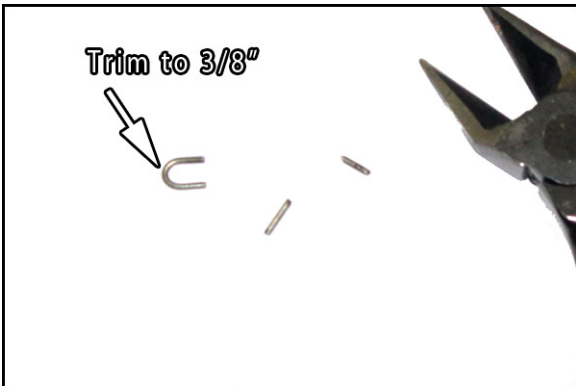
Bend cutoff into U-shape.

5.3.4. ☐ Form Cutoffs around Screwdriver Shaft:



Locate saved cutoffs from resistors and form around a small (1/8") screw driver shaft.

5.3.6. ☐ Trim Cutoff:



Trim cutoffs to 3/8" length to complete U-shaped series jumper. **Make 20 of these jumpers.**

5.4. ☐ PREPARE ALL REQUIRED WIRE LENGTHS:

The following two tables list the required wires that have to be prepared for a stereo pair of CBT36s. The wire size, number of wires, wire length, insulation removal (for both ends) and whether or not the wire should be tinned is specified. If you accidentally tin a wire that shouldn't be, it will not fit in the terminal properly when other wires have to be connected to the same terminal!

All wire is either 18AWG or 24 AWG stranded. See instructions in next two sections. The short section following the tables recaps the preparation of the wires and shows photos of the groups of wires after they are prepared.

Before you start cutting the wires, we suggest preparing a 36" long cutting guide marked off with all the lengths that must be cut. The guide can be as simple as a piece of corrugated cardboard or a wooden plank. The following inch lengths should be marked on this guide: 4", 4.5", 5", 6", 11", 12", 15", 16", 17", 22", 24", 27", 28", 35", and 36". Because keeping track of all the wires is extremely important to minimize mistakes, we suggest you store the completed wire bundles in "press-to-close" plastic bags. A "snack" size 6 1/2" x 3 1/4" (165 mm x 82.5 mm) bag works great for this use. Twenty seven bags are required and should be number consecutively from 1 to 27 following the entries in the following tables.

5.4.1. **18 AWG Stranded-Wire Table:**

Locate the 18 AWG wire for the ND91 Mid-Bass Drivers and cut to the lengths and quantities shown in the following table (**Note:** the listed quantities in this and the following tables are for a pair of CBT36s).

18 AWG Stranded-Wire Table

Cut	Strip	Tin	Item	Qty	Cut to Length (in)	Remove Insulation end 1	Tin Wire	Remove Insulation end 2	Tin Wire	Location Used
18 AWG Stranded Wire - GRAY (Material List Item 25)										
			1	20	6	0.375	No	0.375	No	ND91 - Series Jumpers
18 AWG Stranded Wire - RED (Material List Item 23)										
			2	2	4	0.375	No	0.75	No	ND91 Bank 2 (+) to Series Resistor Jumper
			3	10	6	0.375	No	0.375	No	ND91 - Parallel Jumpers
			4	2	12	0.375	Yes	0.75	No	Speakon Connector (1+) to Bass-Mid input (+)
			5	2	15	0.375	Yes	0.75	No	Speakon Connector (2+) to Tweeter input (+)
			6	2	17	0.375	No	0.375	No	ND91 Bank 1 (+) to ND91 Bank 2 (+) Jumper
			7	2	28	0.375	No	0.75	No	Series Resistor Jumper to ND91 Bank 5 (+)
			8	2	35	0.75	No	0.75	Yes-J	Bass-Mid input (+) to ND91 Bank 1 (+)
18 AWG Stranded Wire - BLACK (Material List Item 24)										
			9	10	6	0.375	No	0.375	No	ND91 - Parallel Jumpers
			10	2	12	0.375	Yes	0.75	No	Speakon Connector (1-) to Bass-Mid input (-)
			11	2	15	0.375	Yes	0.75	No	Speakon Connector (2-) to Tweeter input (-)
			12	2	15	0.75	No	0.75	Yes-J	Bass-Mid input (-) to ND91 Bank 1 (-)
			13	2	17	0.375	No	0.375	No	ND91 Bank 2 (-) to ND91 Bank 3 (-)
			14	2	24	0.375	No	0.375	No	ND91 Bank 1 (-) to ND91 Bank 2 (-)
18 AWG Stranded Wire - YELLOW (Material List Item 26)										
			15	8	4	0.375	No	0.75	No	Jumpers from ND91 Banks 4, 5 to parallel resistors
			16	2	4	0.75	No	0.75	Yes-J	Jumpers from ND91 Bank 3 to parallel resistor
			17	2	11	0.75	No	0.75	Yes-J	Jumper from ND91 Bank 3 (-) to parallel resistor

Notes for the 18 AWG wire table:

For wire ends that need to be "Tinned", heat the wire with an 800 degree soldering iron and apply just enough solder so the wire ends are evenly coated with solder.

Wires 8, 12, 16 and 17, form a "J" shape on the tinned 3/4 inch end.

5.4.2. 24 AWG Stranded-Wire Table:

Locate the stranded 24 AWG wire for the tweeter modules and cut to the lengths and quantities shown in following table: (**Note:** Item 18 is below in the 24 AWG Solid-Wire Table).

24 AWG Stranded-Wire Table

Cut	Strip	Tin	Item	Qty	Cut to Length (in)	Remove Insulation end 1	Tin Wire	Remove Insulation end 2	Tin Wire	Location Used
24 AWG Stranded Wire - RED (Material List Item 28)										
			19	10	4.5	0.25	Yes	0.25	Yes	Tweeter Module Parallel Jumpers
			20	2	15	0.25	Yes	0.25	Yes	Tweeter Module Bank 1 (+) to Tweeter Module Bank 2 (+) Jumper
			21	2	27	0.25	Yes	0.75	No	Series Resistor Jumper to Tweeter Module Bank 5 (+)
			22	2	36	0.75	No	0.25	Yes	Tweeter input (+) to Tweeter Module Bank 1 (+)
24 AWG Stranded Wire - Black (Material List Item 27)										
			23	10	4.5	0.25	Yes	0.25	Yes	Tweeter Module Parallel Jumpers
			24	2	15	0.25	Yes	0.25	Yes	Tweeter Module Bank 2 (-) to Tweeter Module Bank 3 (-)
			25	2	16	0.75	No	0.25	Yes	Tweeter input (-) to Tweeter Module Bank 1 (-)
			26	2	22	0.25	Yes	0.25	Yes	Tweeter Module Bank 1 (-) to Tweeter Module Bank 2 (-)
24 AWG Stranded Wire - Yellow (Material List Item 29)										
			27	4	5	0.25	Yes	0.75	No	Jumpers from Tweeter Module Bank 3, 4, 5 to parallel resistors
			28	2	12	0.25	Yes	0.75	No	Jumper fom Tweeter Module Bank 3 (-) to resistor

Notes for the 24 AWG wire table:

For wire ends that need to be "Tinned", heat the wire with an 800 degree soldering iron and apply just enough solder so the wire ends are evenly coated with solder.

5.4.3. 24 AWG Solid-Wire Table:

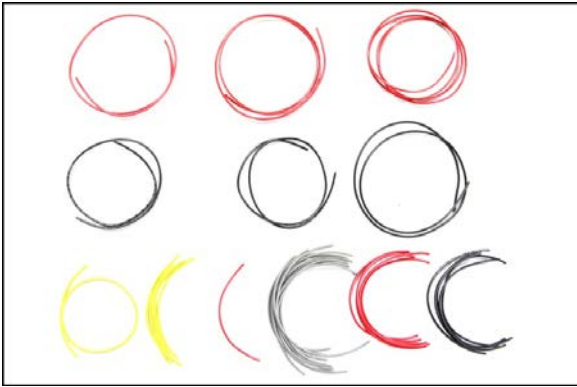
These wires are the wires cutoff from the resistors in the previous Section 5.3 "Configure and Trim the Resistor Leads".

24 AWG Solid-Wire Table (Resistor Lead Cutoffs)

Cut	Item	Qty	Cut to Length (in)	Remove Insulation end 1	Tin Wire	Remove Insulation end 2	Tin Wire	Location Used
Wire cut from Resistor Leads (See Photo Preparing the Resistors Section)								
	18	20	1	n/a	n/a	n/a	n/a	Tweeter Module Series Jumpers

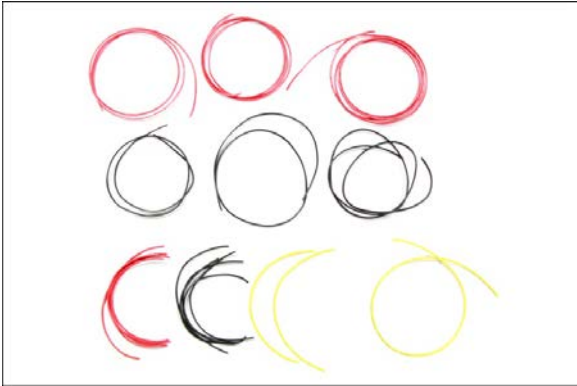
5.5. ☐ CUT WIRE TO LENGTH AND REMOVE INSULATION:

5.5.1. ☐ Cut Lengths for 18 AWG Wire:



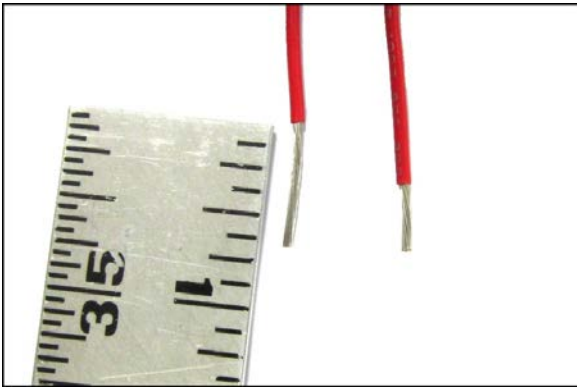
Refer to the wire table, cut wire lengths for 18AWG wire for MID-BASS drivers and Speakon connector (**NOTE:** The wires shown above are for one cabinet only.)

5.5.2. ☐ Cut Lengths for 24 AWG Wire:



Refer to the wire table, cut wire lengths for 24AWG wire for tweeter modules (**NOTE:** wire shown above is for one cabinet only).

5.5.3. ☐ Remove Insulation:

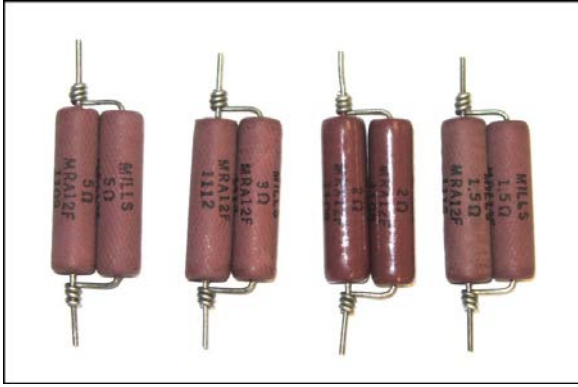


Remove insulation for each wire as designated in the table. (**NOTE:** Some wires are tinned prior to installation.)

5.6. ☐ ATTACH WIRES TO RESISTORS:

The following steps describe attachment of wires to the shading resistors. (**Note:** Two sets of each of the following resistor combinations must be prepared for the left and right pair of CBT36s).

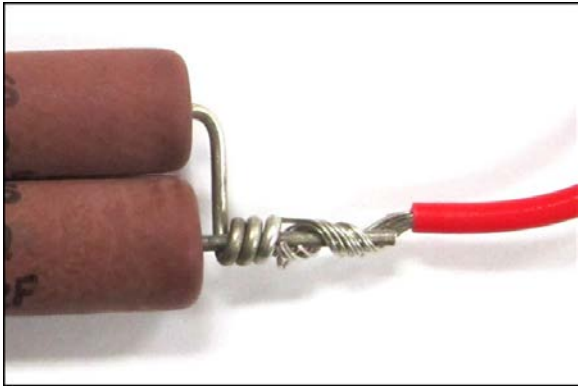
5.6.1. ☐ Locate Parallel Resistors:



Locate parallel resistors configured as shown above, all these are for MID-BASS drivers. Using the following photo as a guide, connect wire as follows:

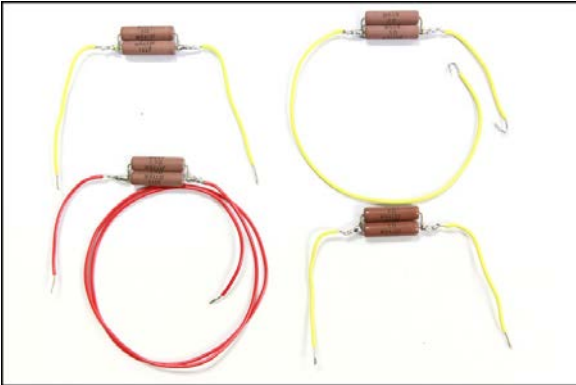
- 1) ☐ 1.5//1.5 Ohm - 4" RED and 28" RED 18 AWG
- 2) ☐ 2.0//2.0 Ohm - 4" YELLOW and 4" YELLOW 18 AWG
- 3) ☐ 3.0//3.0 Ohm - 4" YELLOW and 4" YELLOW 18 AWG
- 4) ☐ 5.0//5.0 Ohm - 4" YELLOW and 11" YELLOW 18 AWG (**NOTE:** These wires are items 16 and 17 in the "18 AWG Stranded Wire" table and have a tinned "J" shape on one end. The "J"-shaped tinned end does not connect to the resistor. The un-tinned end of the wire does connect to the resistor, see following photo for clarification.)

5.6.2. ☐ Connect the Wire to Resistors:



Twist the 18 AWG stranded wire around the appropriate resistor lead (use the end with 0.75 inch of insulation removed that has not been tinned). Apply solder to the resistor leads and the stranded wire. Repeat these steps for all the mid-bass parallel resistors.

5.6.3. ☐ Create Four Parallel Resistor Combinations:



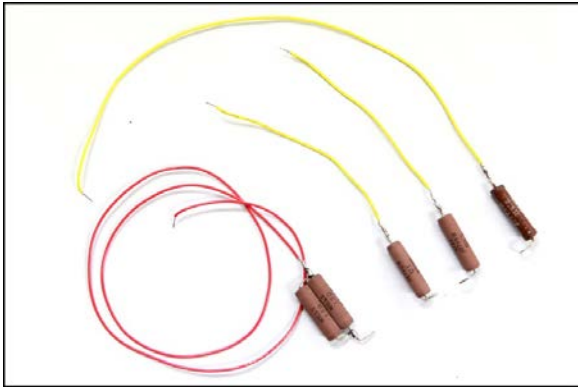
You will end up with two sets of resistors that match the image above. Form a “J” shape at each 3/4 inch wire end that is tinned (see wire table). These are for the ND-91 mid-bass drivers.

5.6.4. ☐ Attach Lead Wires to Parallel Resistor Pair:



Twist the 27” RED 24 AWG wire on the straight end of these resistors (remember to use the end of the wire with 3/4” of insulation removed).

☐ Attach Long Lead Wires to Resistors:



Locate the remaining single resistors and connect wires as follows (**NOTE:** You should have two complete sets of resistors configured as above and listed below).

- 1) ☐ 1.0 Ohm - 5” YELLOW 24 AWG
- 2) ☐ 1.5 Ohm - 5” YELLOW 24 AWG
- 3) ☐ 2.5 Ohm - 12” YELLOW 24 AWG
- 4) ☐ 1.5//1.5 Ohm - 27” RED 24 AWG (Completed in previous step.)

5.7. ATTACH LEAD WIRES TO SPEAKON CONNECTOR:



Locate the Speakon connector and solder wires to the terminals as follows. Note that the wire end that connects to the Speakon connector should be the end that has 0.375” of insulation trimmed off and is tinned. (**NOTE:** You should prepare two complete Speakon assemblies as shown above for the left and right pair of CBT36s.)

- 1) ☐ 12” RED 18 AWG to 1(+)
- 2) ☐ 12” BLACK 18 AWG to 1(-)
- 3) ☐ 15” RED 18 AWG to 2(+)
- 4) ☐ 15” BLACK 18 AWG to 2(-)

6. MOUNT DRIVERS ON FRONT PANEL



THE NEXT STEPS IN THE ASSEMBLY PROCESS REQUIRE PAINTED CABINETS. IF YOU HAVE NOT PAINTED YOUR CABINETS, YOU WILL NEED TO COMPLETE THIS NEXT. ALL THE PRE-WIRING IS NOW COMPLETE AND ONCE YOUR CABINETS ARE PAINTED YOU CAN MOVE TO THE NEXT STEP, INSTALLING THE DRIVERS.

YOUR REWARD FOR DOING ALL THIS WORK AHEAD OF TIME IS THAT THE DRIVER LOADING AND CONNECTING ALL THESE WIRES TO THE DRIVERS WILL GO QUICKLY AND YOU WILL SOON BE LISTENING TO YOUR NEW SPEAKER!

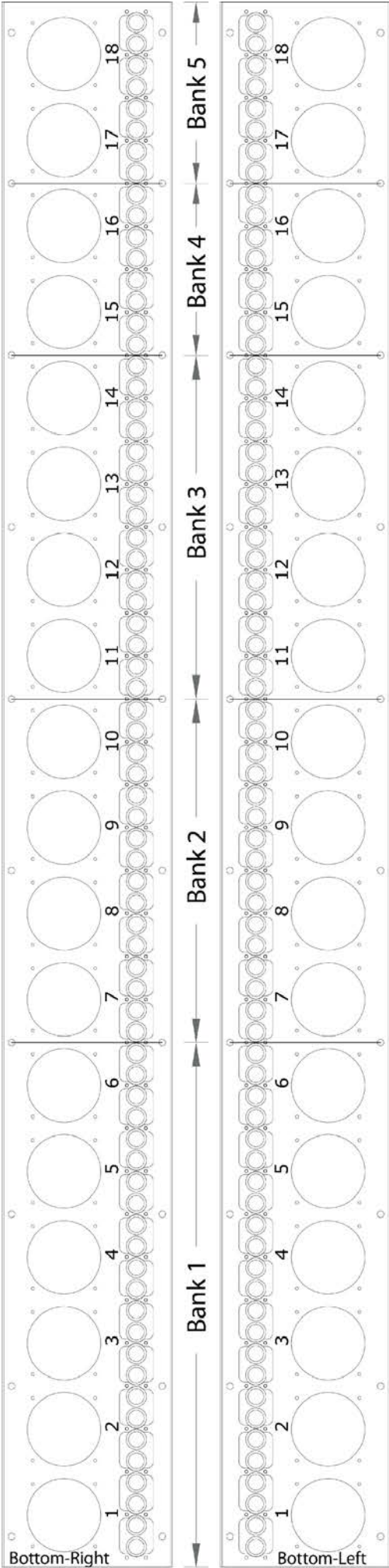
6.1. PREPARE PAINTED FRONT PANELS FOR DRIVERS:

Orient panels face down and label as shown in the line drawing to the right. Label the panels, number each 3.5 inch mid-bass driver position and draw lines between each bank.

Fig. 7. Illustration of the rear side of the right and left front panels showing:

- 1. Bank separation lines,
- 2. Driver numbers (1-18),
- 3. Bank numbers (1-5), and
- 4. Bottom labels.

These markings and indications are added in the following steps.





PROPER ORIENTATION IN THE FOLLOWING STEPS IS CRITICAL TO ENSURE THE WIRING IS CORRECTLY PREPARED.

6.1.1. ☐ Position the Front Panels:

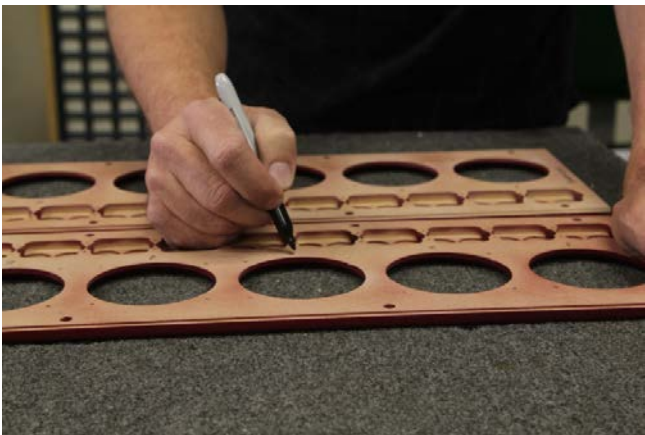


Position panels as shown, face down with tweeter cut outs next to each other.



THIS MIRRORED ARRANGEMENT WILL ENSURE THAT THE WIRE ROUTES POSITION THE INPUT AT THE BOTTOM OF THE PANELS.

6.1.2. ☐ Number each Driver Position:



Using Fig. 7 as a reference, number each driver position and label the bottom of each panel. "Bottom Left", and "Bottom Right".

6.1.3. ☐ Draw Lines Between each Bank:



Using Fig. 7 as a reference, draw lines between each bank; use the line drawing in Fig. 7 to identify the proper locations.



ALTHOUGH THE PANELS ARE MIRRORED, NEITHER THE DRIVERS NOR THE WIRING IS MIRRORED; THIS WAY BOTH PANELS WILL HAVE IDENTICAL WIRE ROUTES.

For example, if the ND91 is rotated such that it is mirrored between the right and left panel, the (+) and (-) terminals will be reversed on right panel and this would require a wiring scheme that differs from those included in this manual.

Follow the directions carefully on the following pages and you won't make a mistake!

6.2. ☐ PARTS AND TOOLS FOR DRIVER INSTALLATION:



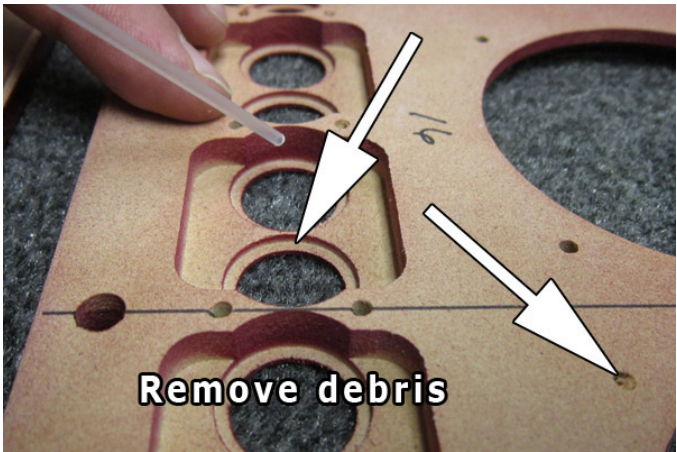
Parts and tools needed for driver installation. This photo shows a layout of the front panels alongside 18 ND91-8 mid-bass drivers, 18 four-tweeter PC modules, a plastic bag of screws, and a battery-operated motorized screw driver.



DRIVERS SHOULD BE TESTED BEFORE INSTALLING ON THEM ON THE FRONT PANELS.

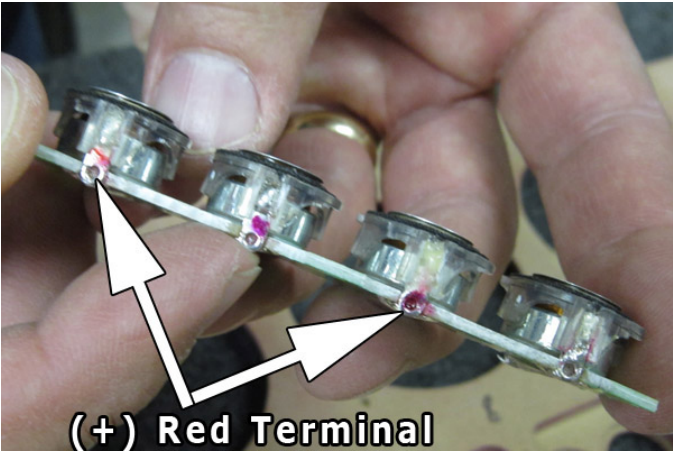
6.3. ☐ MOUNT TWEETER MODULES TO FRONT PANEL:

6.3.1. ☐ Remove Debris from Front Panel:



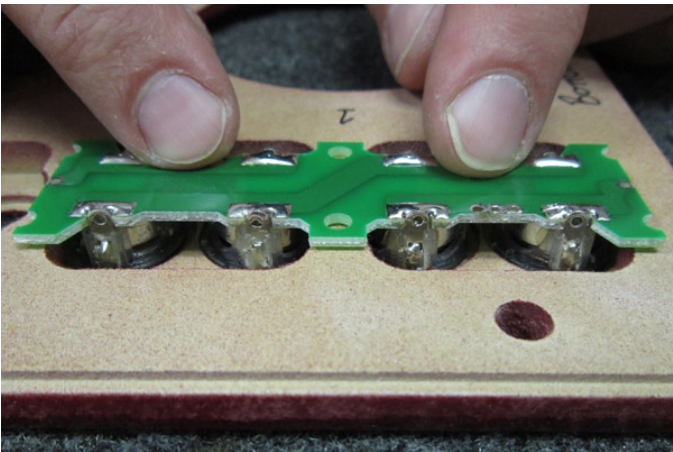
Clear any debris from holes and areas that may restrict the modules from seating into the panel. Use a burst of compressed air for stubborn areas.

6.3.2. ☐ Orient Red Terminals on Tweeter Module:



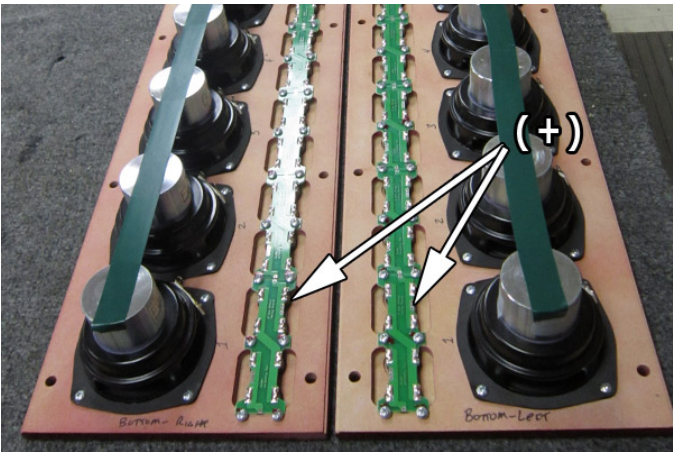
Locate the Red marks on the tweeter module and load each in the panel with the (+) side located as shown in the following images.

6.3.3. ☐ Locate Tweeter Module on Front Panel:



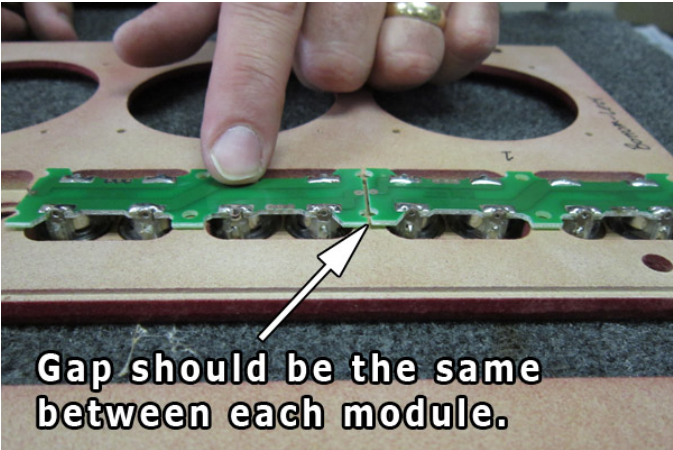
Carefully position the tweeter modules on the panel. Be sure to check the location of the red terminal for proper orientation.

6.3.4. ☐ Tweeter Module (+) Terminal Orientation:



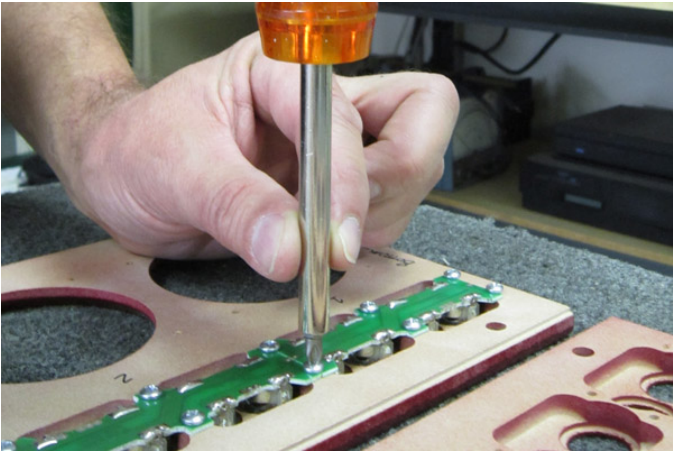
The (+) tweeter terminals will be on the right when looking from the bottom of the panels. The tape covering the rear holes of the mid-bass drivers will be added later in section 6.4.5. The tape prevents debris from entering the driver through these holes.

6.3.5. ☐ Align the Tweeter Modules on the Front Panel:



Gently move the modules so the gaps near the ends are consistent and the ends are aligned. The width of the gap is not important. Just make sure all the modules are inserted uniformly with all the rear surfaces at the same height.

6.3.6. ☐ Attach Tweeter Modules to Front Panel:



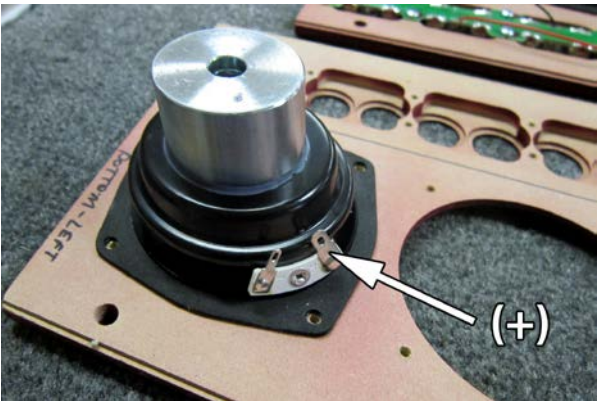
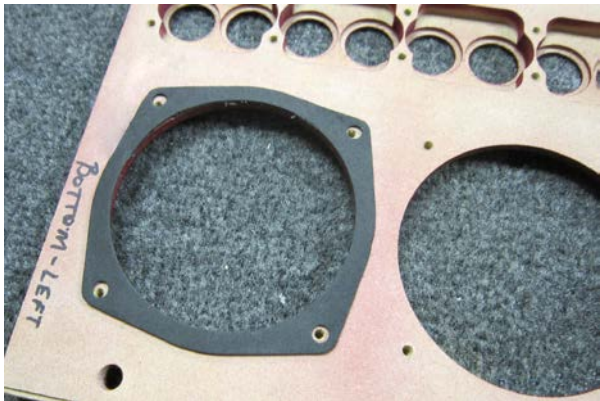
Install all tweeter modules using the 6-32 x 5/16 screws (Material List item 7). Do not over tighten because the MDF material will strip out easily. If you do strip a hole, this is easily repaired by a drop of Super Glue (see Caution in Section 6.4.2 on next page).

6.4. ☐ MOUNT ND-91 MID-BASS DRIVERS TO FRONT PANEL:



DRIVER AND TWEETER MODULE ORIENTATION IS CRITICAL TO ENSURE BOTH PANELS CAN BE WIRED PER THE INCLUDED WIRING DIAGRAM. IMPROPER ORIENTATION WILL CAUSE THE (+) AND (-) TERMINALS TO BE REVERSED.

6.4.1. ☐ Position Gasket and Mid-Bass Driver on Front Panel:



Before the ND91 3.5" mid-bass driver can be mounted to the rear of the front panel, a gasket (item number 23 in the Material List) must be located over the driver mounting hole (left photo). After the gasket is positioned, the mid-bass driver can be placed (right photo), terminals should be at the top right when looking at the panel from the bottom. Note that the driver itself has a un-used gasket attached to its rear.

6.4.2. ☐ Install Mid-Bass Drivers on Front Panel:



Install all the ND91 mid-bass drivers with the supplied 6-32 x 5/16 screws (Material List item 7). Again, avoid over tightening and damaging the MDF threads in the front panel.



DO NOT OVER TIGHTEN AND STRIP THE THREADS IN THE MDF. DAMAGED HOLES CAN BE REPAIRED WITH A DROP OF THIN (NOT GEL) SUPER GLUE.

6.4.3. ☐ Remove Protective Plastic from Rear of Mid-Bass Drivers:



Remove the protective plastic from the ND91 magnet.

6.4.4. ☐ Avoid Debris Falling into Magnet Hole:



Avoid any debris entering the hole on the rear of the ND91 magnet assembly.

6.4.5. ☐ Cover Mid-Bass Magnet Holes with Tape:



After all ND91 mid-bass drivers are installed, run a strip of electrical tape over the holes. This will be removed later. Brush a small amount of nail polish on each screw head where it contacts the driver/PCB. For an example of the nail polish being applied to a screw, see photo on top of page 57 in section 6.4.4.3. The nail polish will prevent the screw from coming out and will also indicate that the screw is tightened properly.

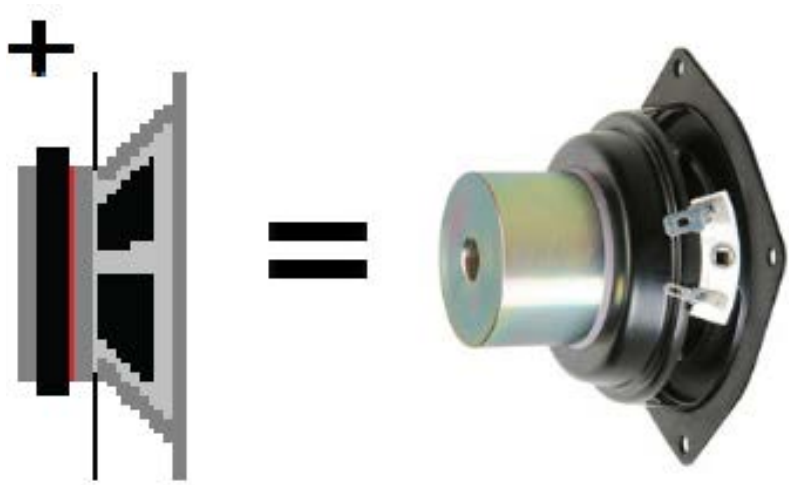
7. DRIVER WIRING:

7.1. MID-BASS SHADING-NETWORK SCHEMATIC:

In this and the following major sections, the mid-bass schematic, mid-bass wiring diagrams, photos are shown. What's the difference between a schematic and a wiring diagram? The schematic shows the traditional diagram of how the parts are connected, while the wiring diagram shows the physical placement of the wires and resistors and where they attach to the speakers.

7.1.1. Mid-Bass Driver Symbol:

The following speaker symbol represents the ND91-8 mid-bass driver:



7.1.2. Mid-Bass Schematic:

The following diagram shows the schematic of the mid-bass shading network. All five shading banks are shown. Banks 1 and 2 are shaded by series-parallel network combinations. Banks 3, 4, and 5 are shaded with resistive attenuators. Refer to Appendix 2: CBT Theory of Operation for more information about CBT shading and the CBT36 shading implementation.

The schematic shows the colors of the insulated jumper wires and where they connect. The physical wiring itself is shown in the following wiring diagrams.

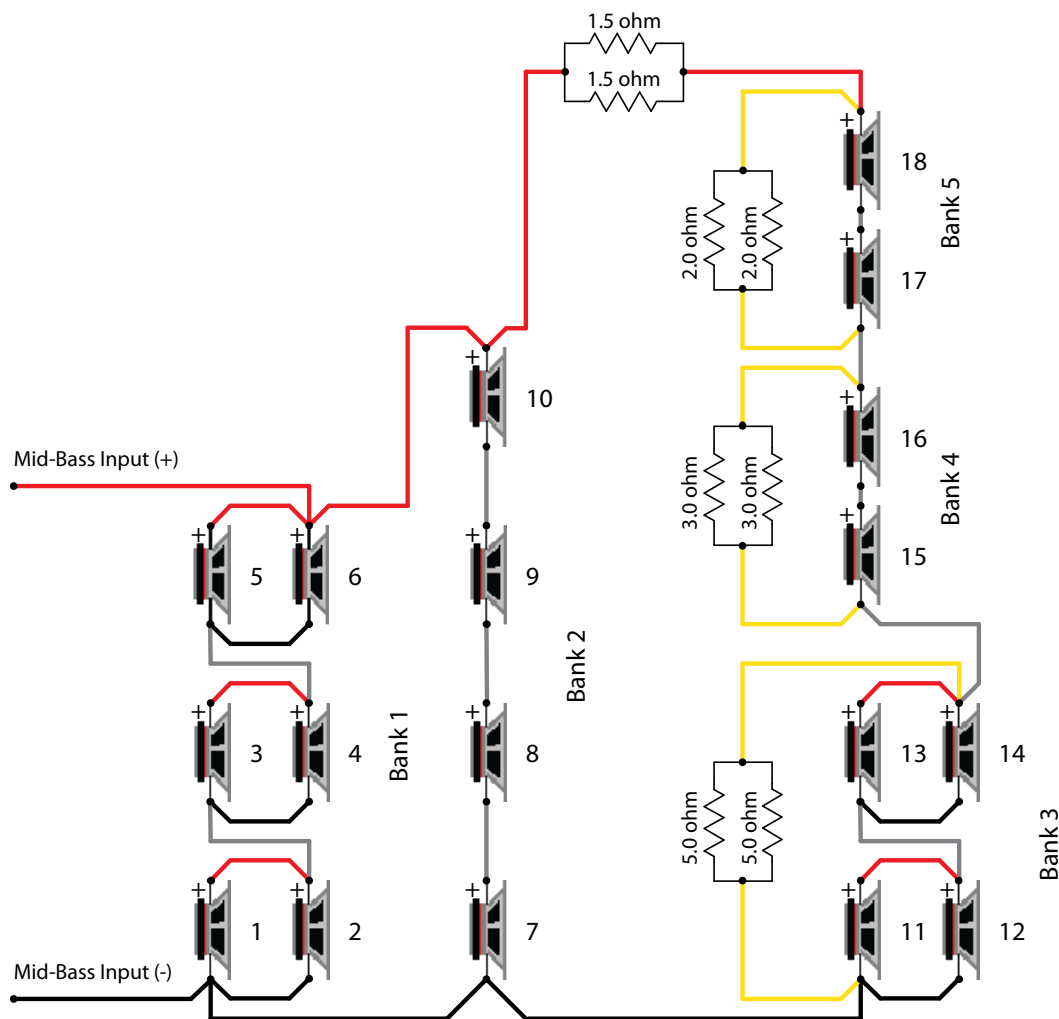


Fig. 8. CBT36 mid-bass shading network schematic.

7.2. MID-BASS SHADING BANK WIRING DIAGRAMS AND ASSEMBLY STEPS:

The next subsections show where each wire and resistor are placed on and around the mid-bass drivers. Install all 18 AWG mid-bass wires for **BOTH** panels prior to soldering. After all wires are installed, inspect your work and verify all connections and then solder. *Remember, it's much easier to correct wiring errors if the connections aren't soldered!*

We suggest that you install the 18 AWG wires in the following order for each panel, i.e. for the first step, go across and install all ten gray jumper wires on all the drivers on each panel. At this point, you don't need to wrap the wire around the terminal, just stick it through the terminal and leave it straight! This is clearly shown in the next photo in the "Bank 1 Wiring Diagram" section which follows.

Once the wires are all inserted and you have made sure that all the connections are correct, then go back and wrap them all. After all are wrapped, then solder all terminals. For wiring reference, the following wiring diagrams show each of the five shading banks. After all wires have been attached, you should refer to the full-size fold-out wiring diagrams and rear-panel photos at the end of this manual as an additional wiring reference.

- 1) ☐ 6 inch GRAY jumpers (10 each).
- 2) ☐ 6 inch RED jumpers (5 each).
- 3) ☐ 6 inch BLACK jumpers (5 each).
- 4) ☐ Resistors with YELLOW jumpers (Banks 4 and 5).
- 5) ☐ Resistor with RED jumper (Bank 2 to Bank 5).
- 6) ☐ RED bank jumper (Bank 1 to Bank 2).
- 7) ☐ BLACK bank jumpers (Bank 1 to Bank 2 and Bank 2 to Bank 3).
- 8) ☐ Resistor with YELLOW jumper (Bank 3).
- 9) ☐ RED jumper to Speakon connector.
- 10) ☐ BLACK jumper to Speakon connector.

7.2.1. Bank 1 Wiring Diagram:

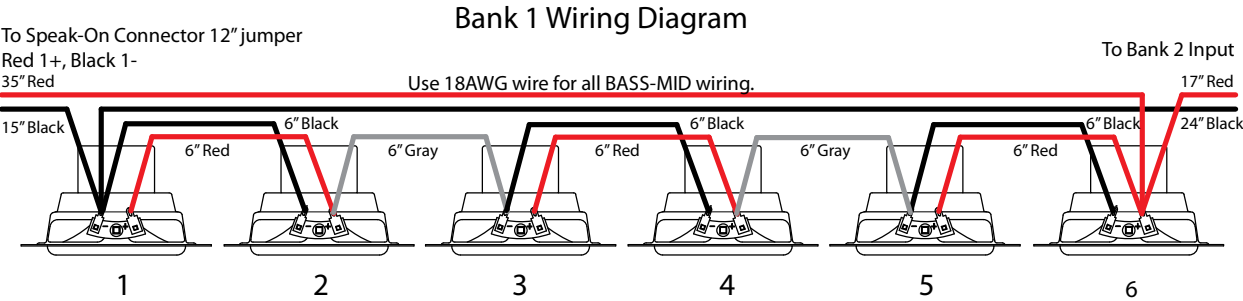
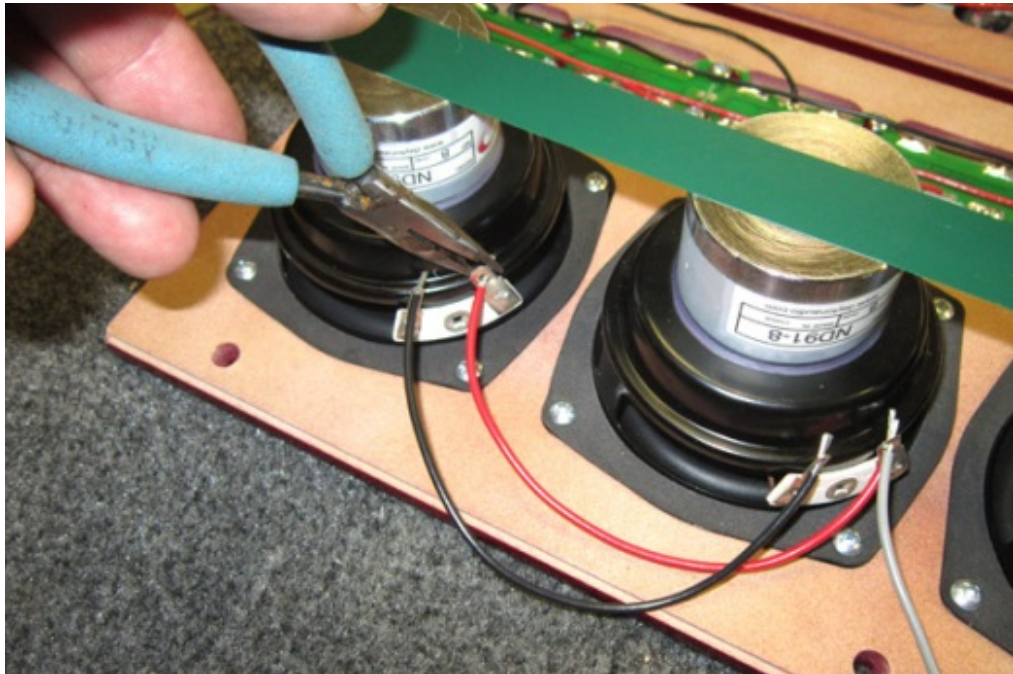


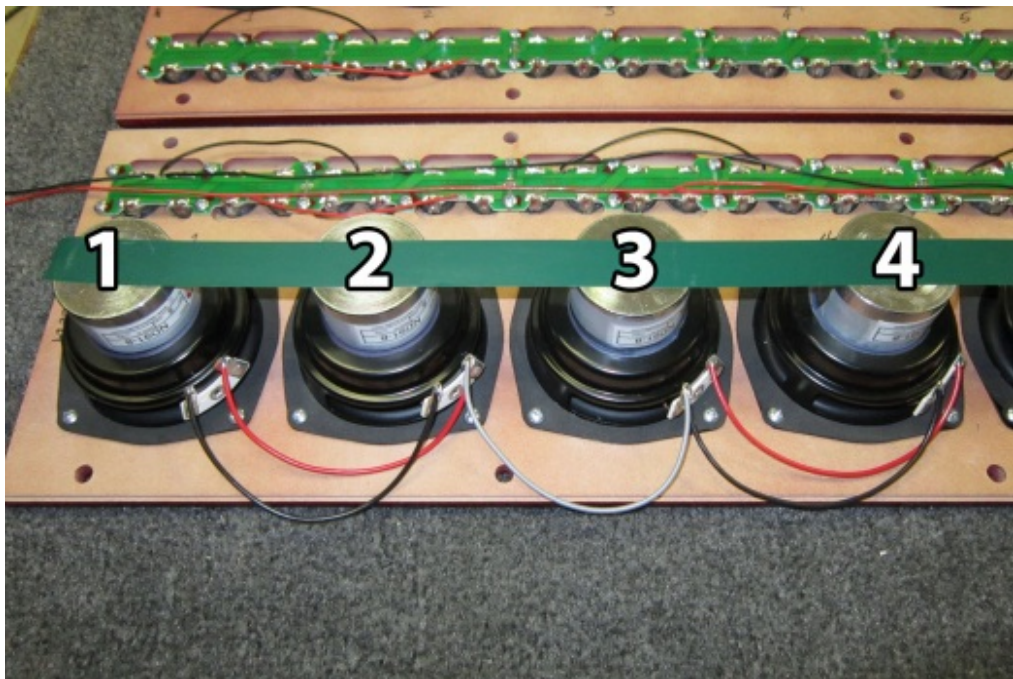
Fig. 9. Bank 1 wiring diagram for mid-bass drivers 1 to 6.

7.2.1.1. Insert Twisted Stranded Wire into Mid-Bass Terminals:



After twisting the wire to minimize stray strands, insert the wire into each terminal and leave the wire straight. After all wires have been inserted, then go back and wrap them around the driver terminals.

7.2.1.2. After all Mid-Bass Jumper Wires are Installed, You Can Go Back and Wrap them Around the Terminals:



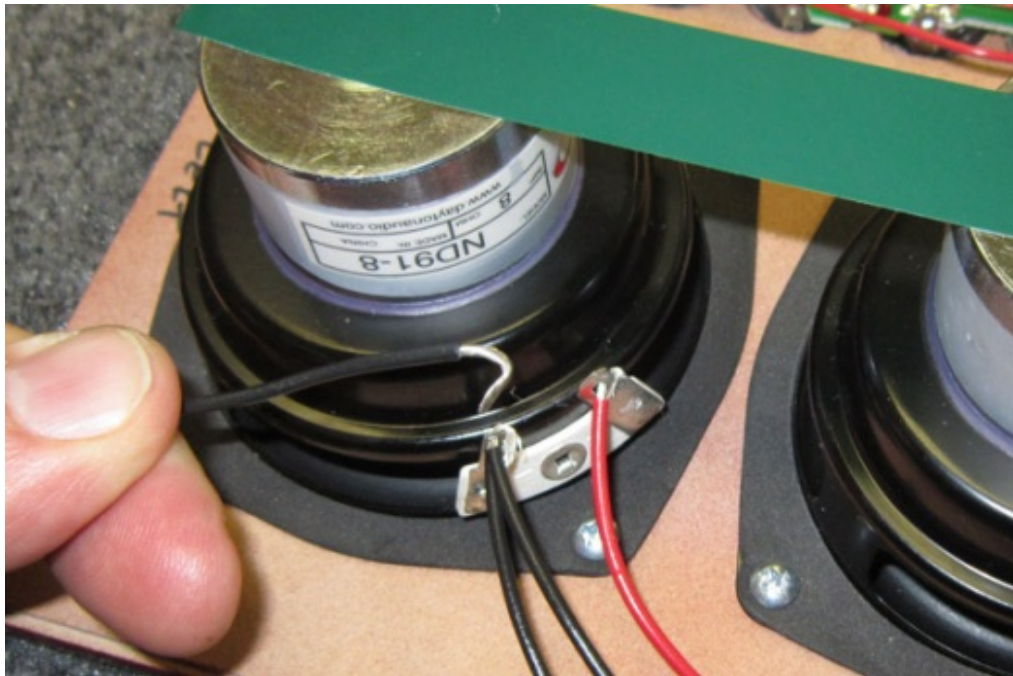
This photo shows all the mid-bass jumper wires for drivers 1, 2, 3, and 4 installed but not soldered. Some drivers have two wires in each terminal. After all wires are installed correctly, then go back and twist them around the terminals in preparation for soldering. The next two photos illustrate proper wrapping techniques.

7.2.1.3. Close-up View of Wire Wrapped Around Terminal on Mid-Bass Driver:



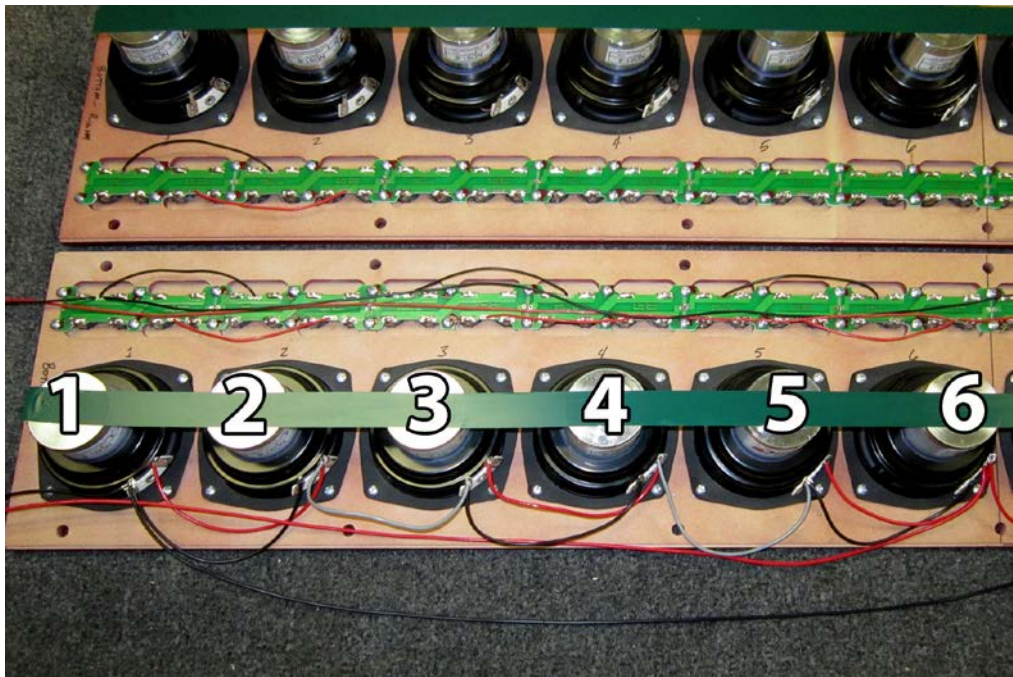
View of red wire wrapped around the (+) terminal of the ND91.

7.2.1.4. Procedure to Hook Three Wires to Mid-Bass Terminal:



Only two wires will fit in the ND91 terminal. At locations that require three wires, form a J-hook and wrap around the terminal.

7.2.1.5. Final view of Mid-Bass Bank 1 Drivers with all Connections Secured:



This is what Bank 1 should look like with all six ND91 mid-bass drivers connected. Compare your work with this photo.

7.2.2. Bank 2 Wiring Diagram:

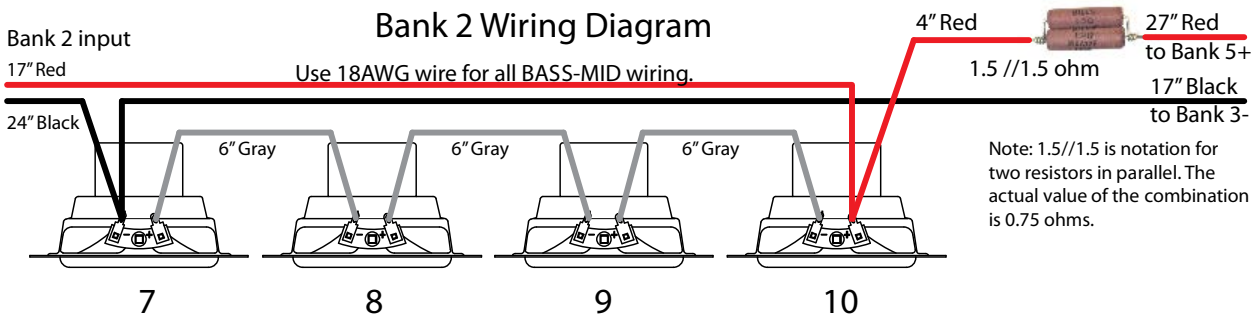
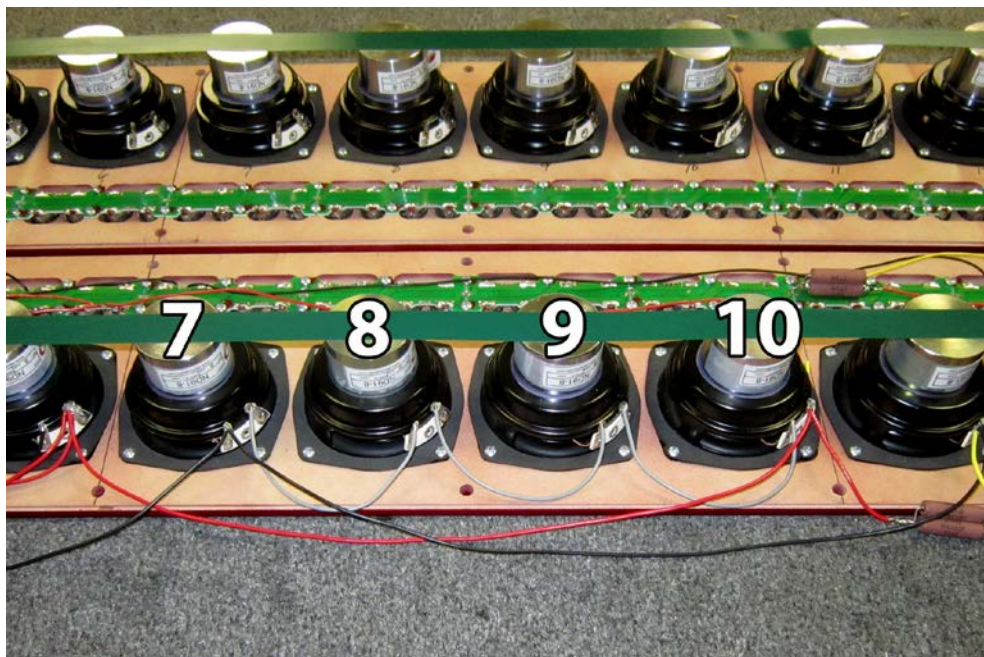


Fig. 10. Bank 2 wiring diagram for mid-bass drivers 7 to 10.

7.2.2.1. Final view of Mid-Bass Bank 2 Drivers with all Connections Secured:



Compare your work against this photo after wiring Bank 2.

7.2.3. Bank 3 Wiring Diagram:

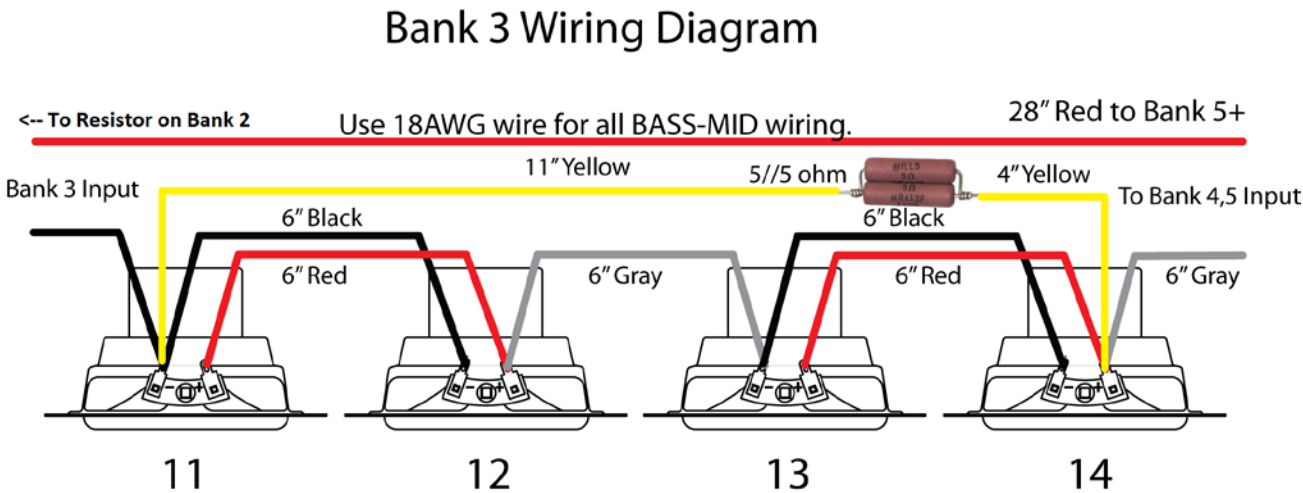
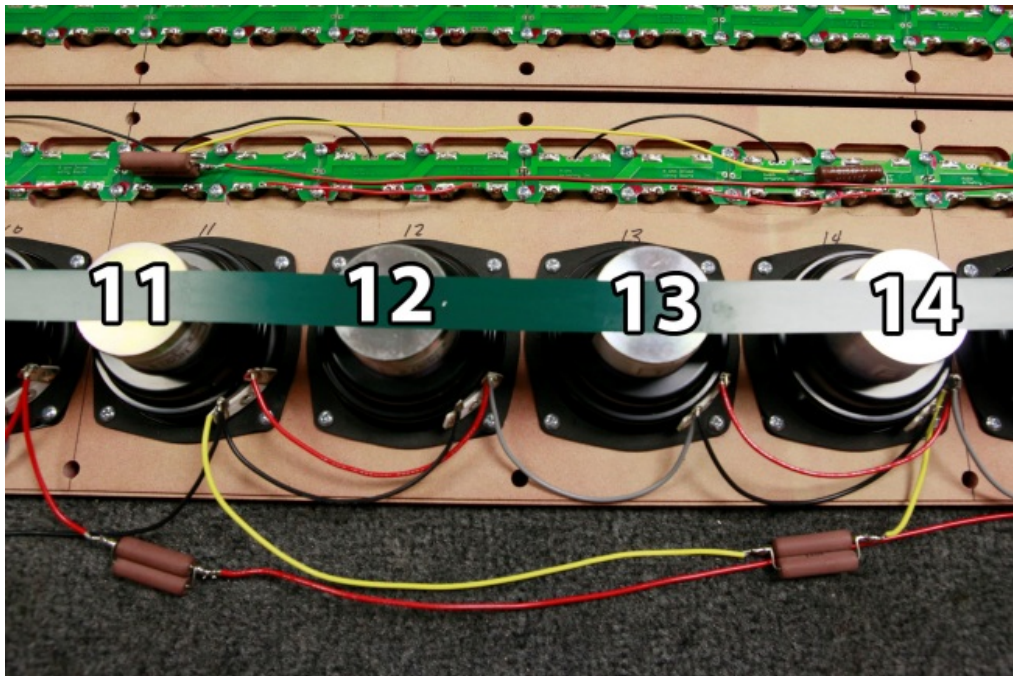


Fig. 11. Bank 3 wiring diagram for mid-bass drivers 11 to 14.

7.2.3.1. Final view of Mid-Bass Bank 3 Drivers with all Connections in Place:



View of Bank 3 wiring. Compare your work with this photo after wiring. Position the wires and resistors as shown in the photo until all soldering is complete.

NOTE: The dangling resistors in the above and the following photo will later be attached to the backs of the drivers with adhesive.

7.2.4. Banks 4 and 5 Wiring Diagram:

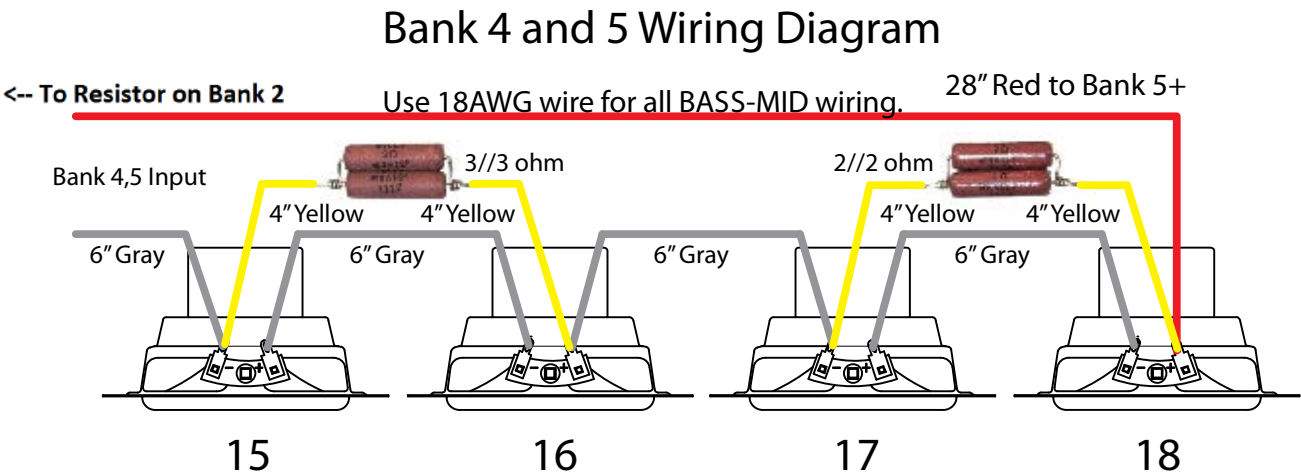
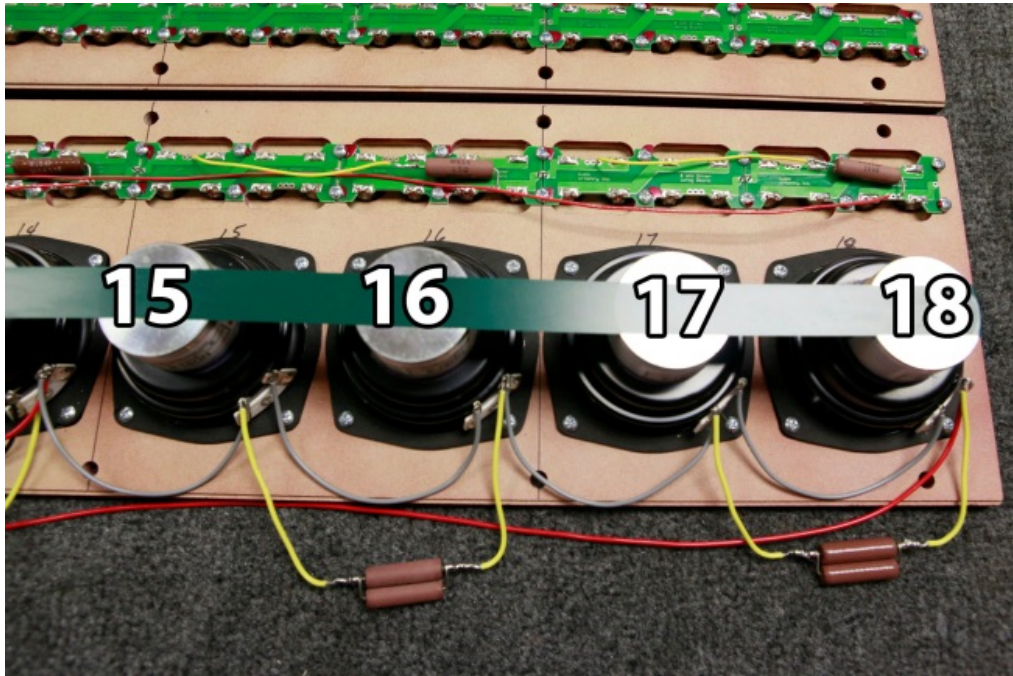


Fig. 12. Banks 4 and 5 wiring diagram of the mid-bass shading network for mid-bass drivers 15 to 18.

7.2.4.1. Final view of Mid-Bass Bank 4 and 5 Drivers with all Connections in Place:



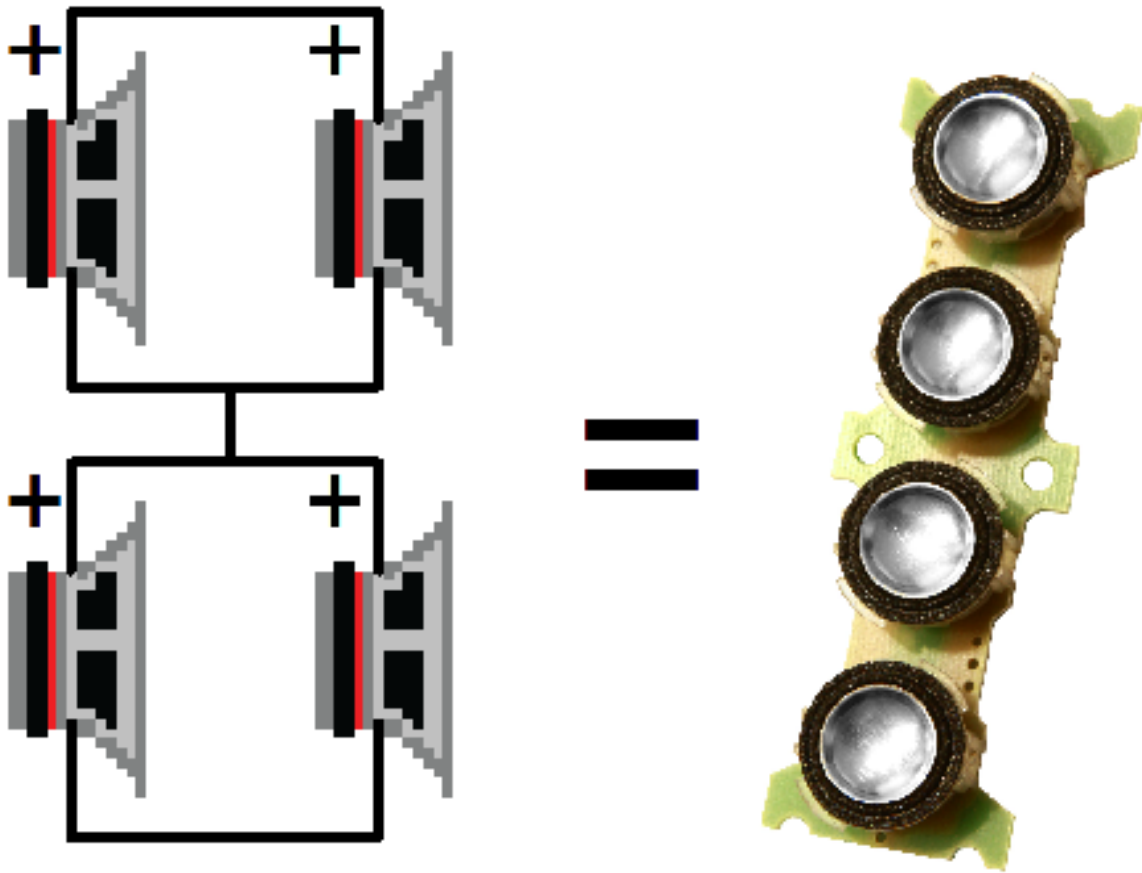
View of mid-bass drivers in banks 4 and 5 after wiring. After all wiring is installed and you have verified resistors are in the correct location, *solder all connections for all five mid-bass banks.*

7.3. TWEETER MODULE SHADING-NETWORK SCHEMATIC:

In this and the following sections, both the tweeter schematic and tweeter wiring diagrams are shown.

7.3.1. Tweeter Module Symbol:

The following symbol represents the tweeter four-driver PC board module:



7.3.2. Tweeter-Module Schematic:

The following diagram shows the schematic of the tweeter-module shading network. All five shading banks are shown. Banks 1 and 2 are shaded by series-parallel network combinations. Banks 3, 4, and 5 are shaded with resistive attenuators. Refer to Appendix 2: CBT Theory of Operation for more information about CBT shading and the CBT36 shading implementation.

The schematic shows the colors of the insulated jumper wires and where they connect. Also shown are the locations of the U-jumpers and resistor-lead connections which are shown in dashed lines. The physical wiring itself is shown in the following wiring diagrams and photos.

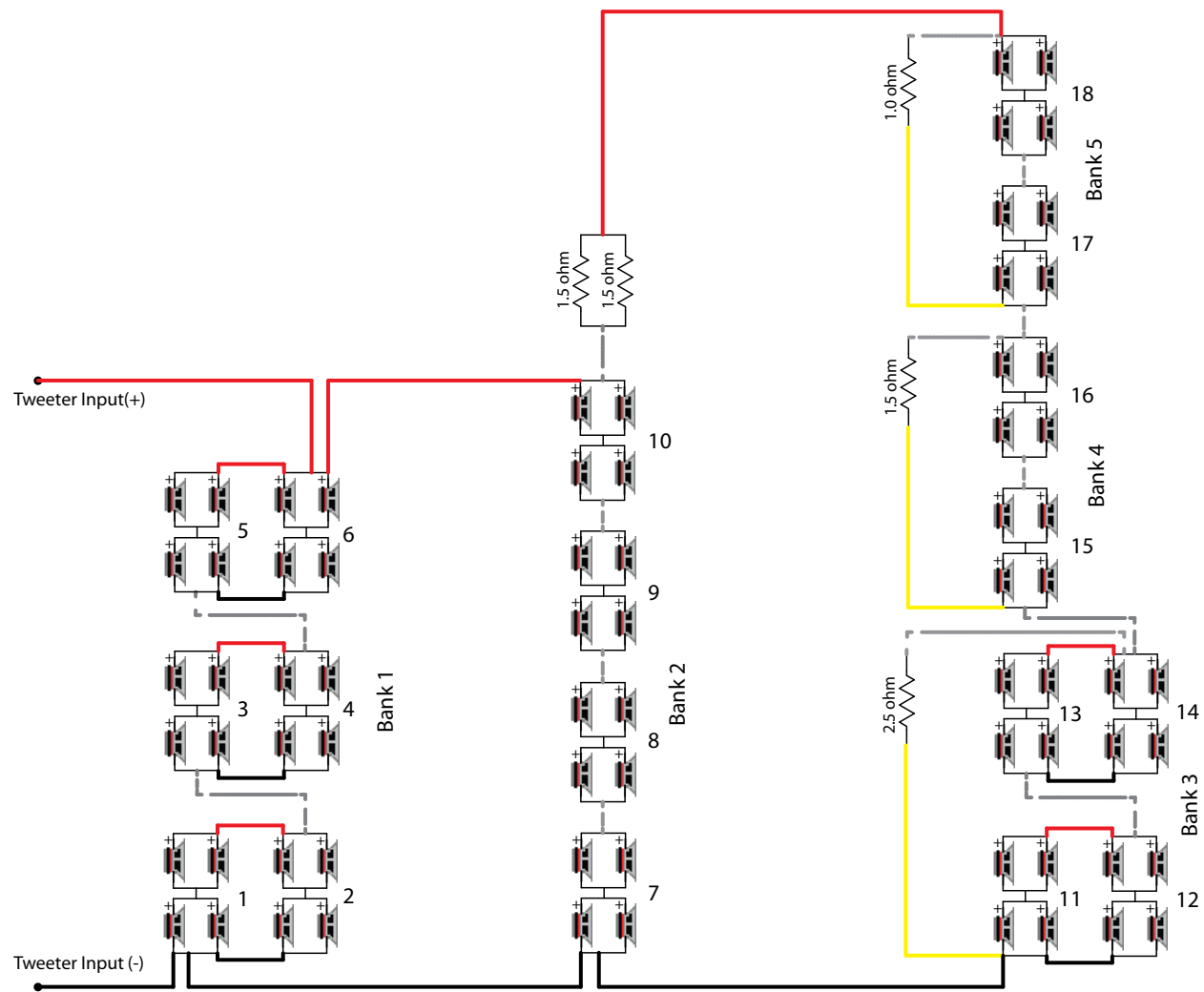


Fig. 13. CBT36 tweeter shading network schematic. The dashed lines are U-jumpers or resistor leads soldered to the PC board.

7.4. TWEETER-MODULE SHADING BANK WIRING DIAGRAMS AND ASSEMBLY STEPS:

The next sub sections show where each wire and jumper are located on the tweeter modules. Install all 24 AWG wires for **BOTH** panels prior to soldering, perform an inspection and then solder. As mentioned before, it's much easier to correct wiring errors if the connections aren't soldered!

For each panel we suggest installing the wires in the following order:

- 1) ☐ Series "U"-shaped jumpers (10 each).
- 2) ☐ 4.5" RED jumpers (5 each).
- 3) ☐ 4.5" BLACK jumpers (5 each).
- 4) ☐ Resistors with RED and YELLOW jumpers.
- 5) ☐ Remaining RED and BLACK bank jumpers.

For wiring reference, the following wiring diagrams, and photos show each of the five tweeter shading banks and where the individual jumpers and colored wires are connected. After all wires have been attached, you should also refer to the full-size fold-out wiring diagrams and rear-panel photos at the end of this manual as an additional wiring reference.

7.4.1. Bank 1 Tweeter Wiring Diagram:

To Speak-On Connector 15" Jumper
Red 2+, Black 2-
16" Black

Bank 1 Wiring Diagram

To Bank 2 Input
22" Black

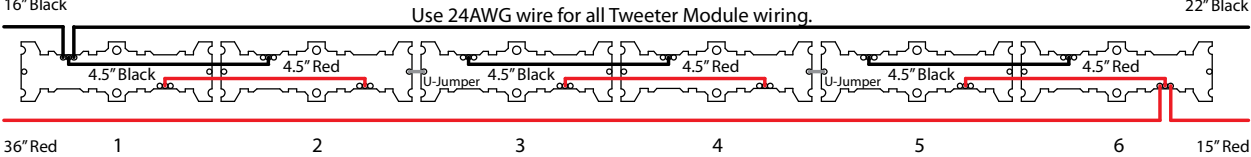
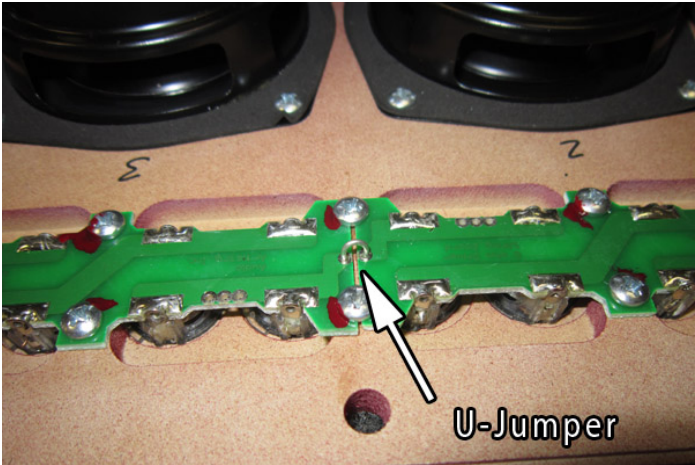


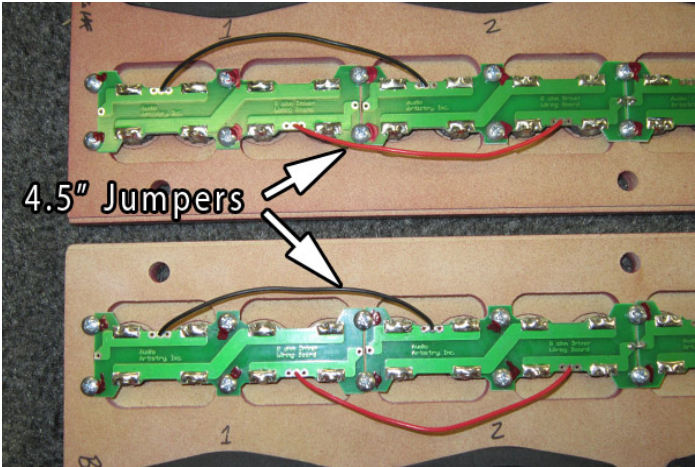
Fig. 14. Bank 1 wiring diagram for the tweeter-module shading network.

7.4.1.1. Close-up View of a U-Jumper Between Two Tweeter Modules:



All 20 U-Jumpers used to connect the tweeters were created from the resistor lead cutoffs. You will install 10 of these U-Jumpers on each front panel. Notice in the following diagram that the first two tweeter modules do not have these series U-Jumpers but instead are connected with wire. Refer to the wiring diagram for each of the banks and notice that some locations don't use series U-jumpers but rather use red and black stranded insulated wire as parallel jumpers. This is illustrated in the next photo.

7.4.1.2. Close Up of Insulated Wire Jumpers Between Tweeter Modules 1 and 2:



View of tweeter modules 1 and 2 with 4.5 inch insulated wire jumpers installed. Position the jumper wires so that about 1/8" of bare lead is exposed for soldering.

7.4.2. Bank 2 Tweeter Wiring Diagram:

Bank 2 Wiring Diagram

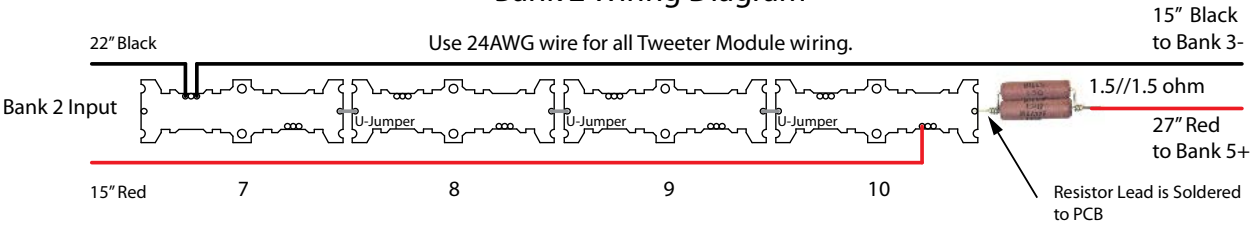
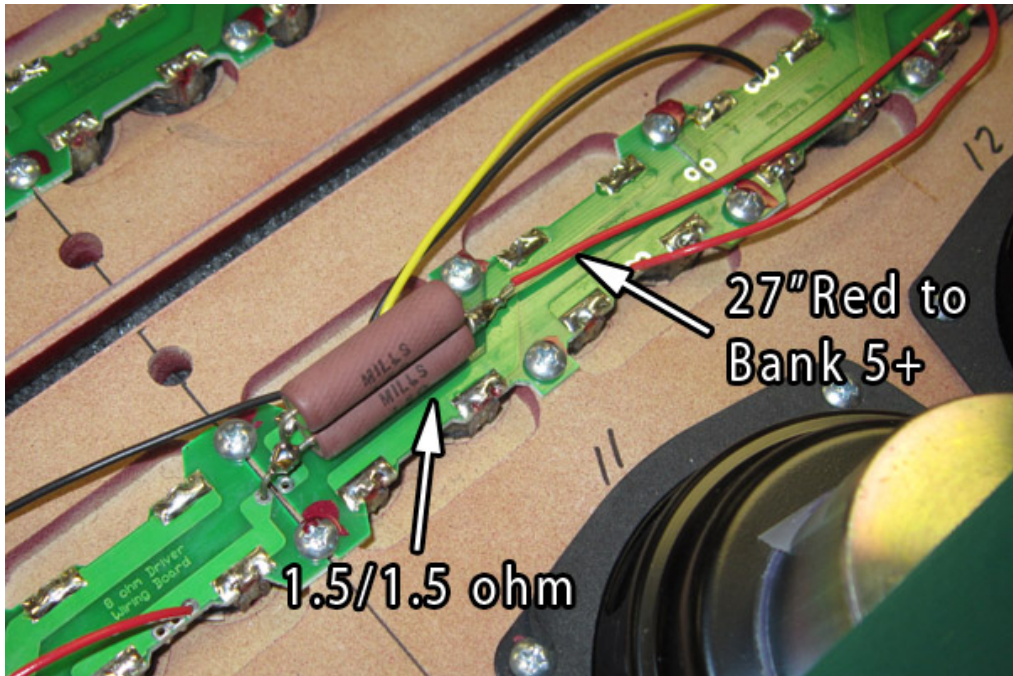


Fig. 15. Bank 2 wiring diagram for the tweeter-module shading network.

7.4.2.1. Close-Up View of Parallel Resistor Combination:



View of 1.5//1.5 Ohm parallel resistor combination installed on the rear of tweeter module 11. Note that the resistor pair connects to the hole on the right end of tweeter module 10 but is mounted on the rear of tweeter module 11 in bank 3. For clarification examine the photo above and refer to the bank 2 wiring diagram shown previously in Fig. 15.

7.4.3. Bank 3 Tweeter Wiring Diagram:

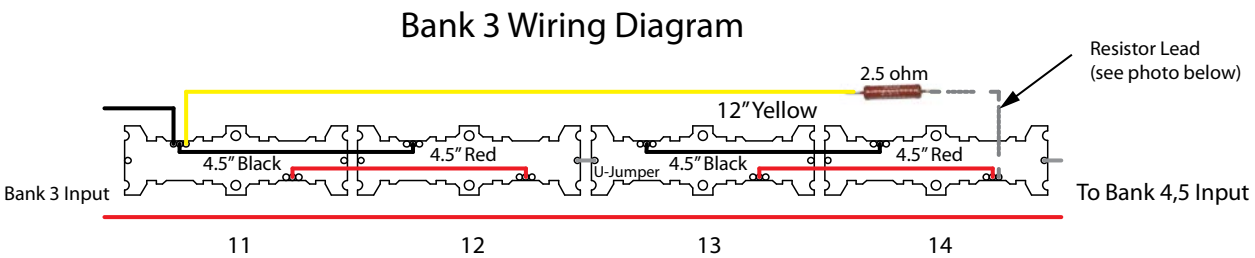
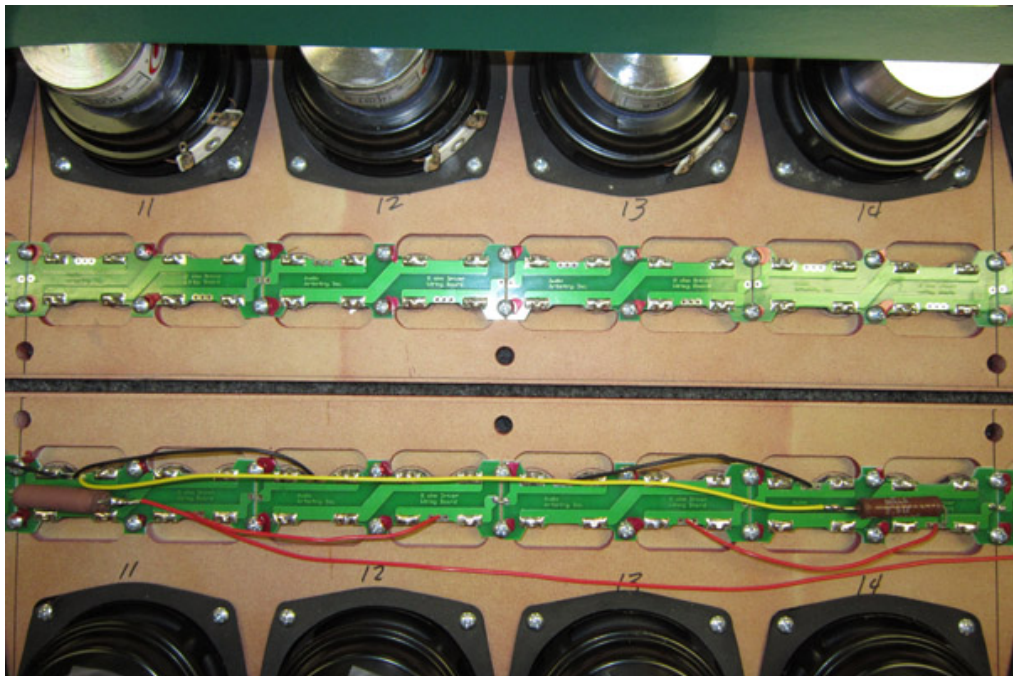


Fig. 16. Bank 3 wiring diagram for the tweeter-module shading network.

7.4.3.1. View of Bank 3 Tweeter-Module Wiring:



View of bank 3 wiring (lower front panel) showing U-jumpers, insulated wire jumpers, and shading resistors installed.

7.4.4. Banks 4 and 5 Tweeter Wiring Diagram:

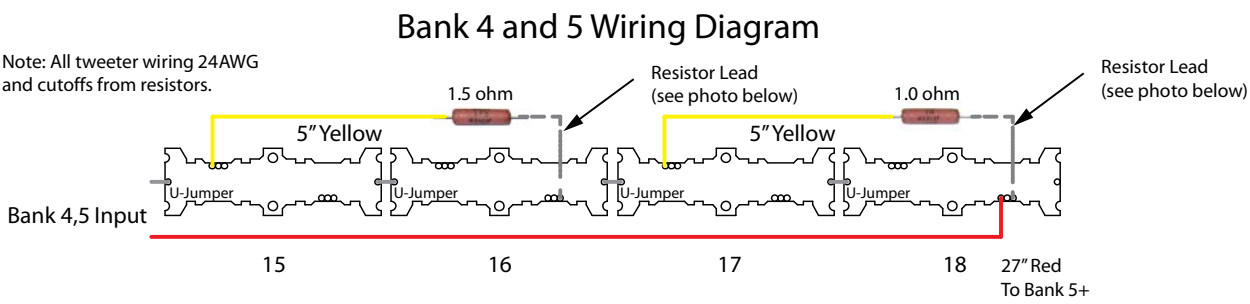
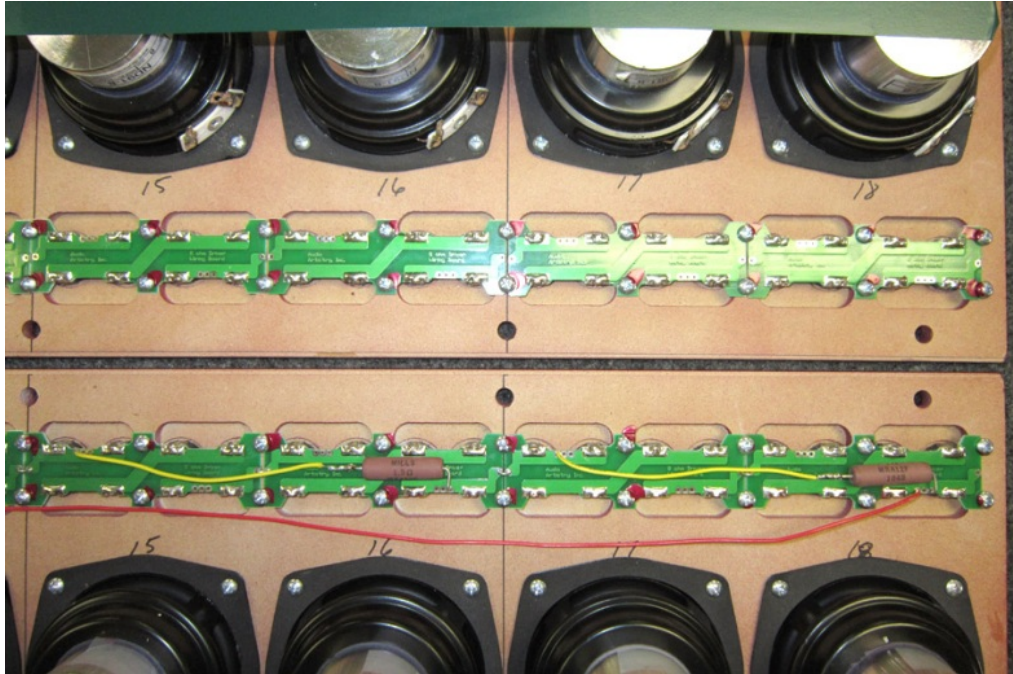


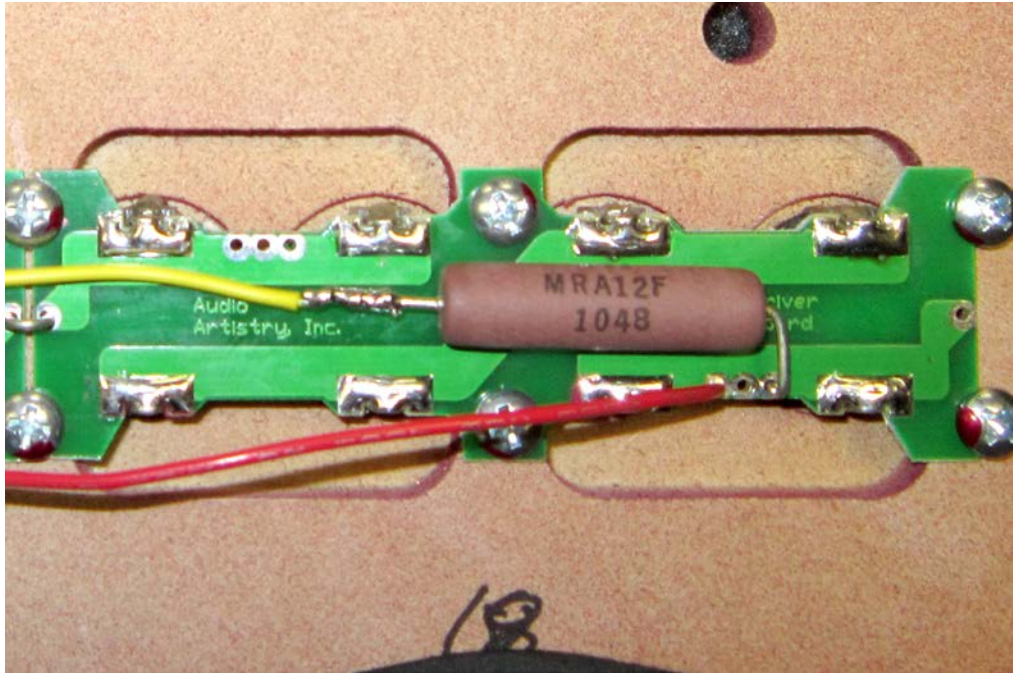
Fig. 17. Banks 4 and 5 wiring diagram of the tweeter-module shading network.

7.4.4.1. View of Banks 4 and 5 Tweeter-Module Wiring:



View of Banks 4 and 5 wiring (lower front panel) showing U-jumpers, insulated wire jumpers, and shading resistors installed.

7.4.4.2. Close-up View of Attachment of Resistors to PC Board:



This close-up view clarifies attachment of the resistors to tweeter-modules 16 and 18.

7.4.4.3. Soldering Insulated-Wire Jumpers to PC Board:



Make sure wire is exposed before soldering. Note the nail polish applied to the mounting screw. The nail polish will prevent the screw from coming out and will also indicate that the screw is tightened properly.

8. SOLDER CONNECTIONS, DRESS THE WIRING, AND MOUNT RESISTORS:

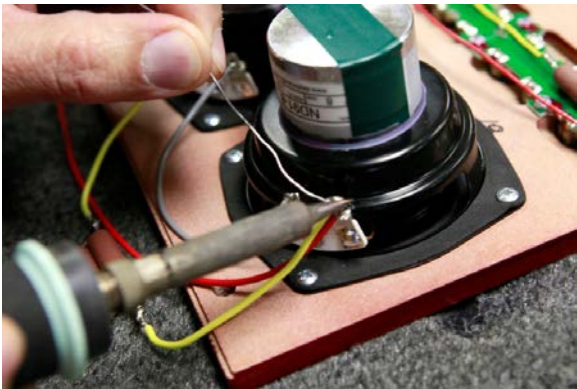
8.1. ☐ FINAL WIRING CHECK:

 **Important!** Using the full-size front-panel foldout diagram found at the end of this manual or packed separately, carefully compare your wiring to the foldout and check for errors before proceeding to the following steps.

8.2. ☐ SOLDER LEADS TO MID-BASS DRIVERS AND TWEETER MODULES:

The following steps indicate how to finish the driver installation by showing how to solder each of the connections to the mid-bass drivers and tweeter modules.

8.2.1. ☐ Solder all ND91 mid-bass driver terminals:



Start at the top and work your way down the line soldering all ND91 mid-bass terminals. Check each connection to make sure all wires are securely soldered, especially terminals with three wires attached.

8.2.2. Prepare to Solder All Tweeter Module Connections:

Start at the top tweeter module and work your way down toward the bottom.

8.2.3. ☐ Solder Insulated-Lead Connections Attached to Tweeter Modules:

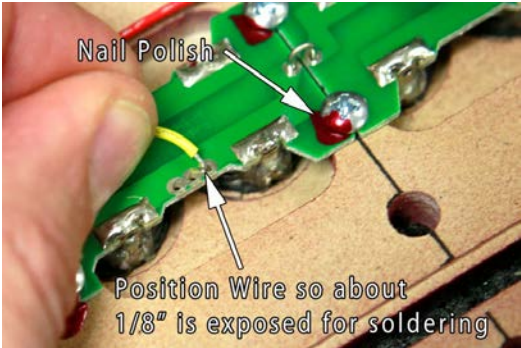
The next four photos indicate how to solder the insulated leads, resistor leads and the U-jumpers to the tweeter-module PC board.

8.2.3.1. ☐ Soldering Insulated and Resistor Leads:



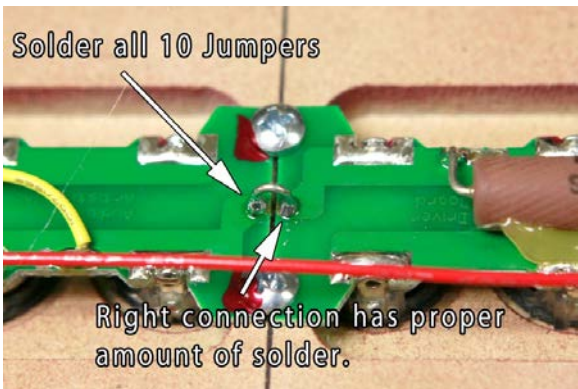
Insulated leads require a little extra attention. First, heat the PCB and apply some solder then lift the lead about 1/8" and allow the solder to flow around the exposed wire. This isn't hard to do, but you may find it easier to use one of the clips on the test lead to help hold the wire in position so both hands are free to handle soldering iron and solder.

8.2.3.2. ☐ Watch Out for Cold-Soldered Joints!:



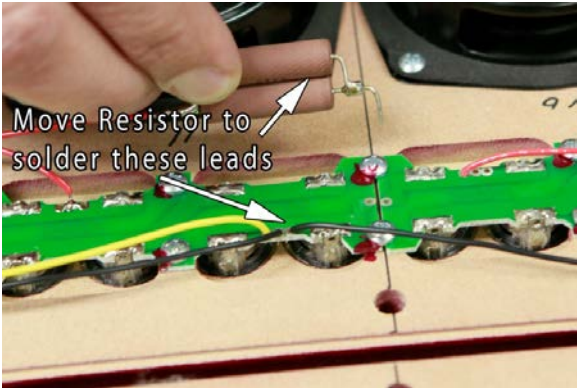
This image was shown earlier but repeated here for convenience. Solder must get to the tinned portion of the wire. Solder can build up around the insulation and appear to be connected even though no connection exists. This is a form of cold-soldered joint.

8.2.3.3. ☐ Solder All U-Jumpers Connecting PC Boards:



Solder all 10 series jumpers on each front panel, these are easy to forget.

8.2.3.4. ☐ *Temporarily Move Resistors to Make Soldering Easier:*

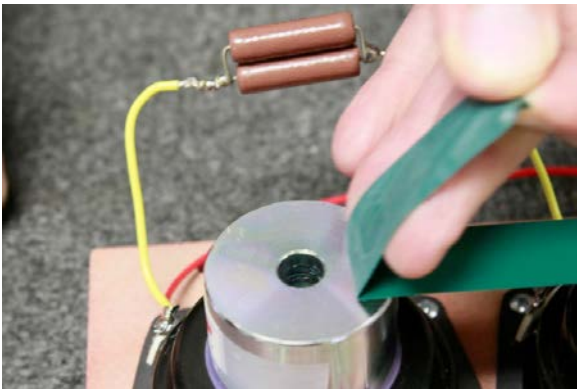


It is easier to solder some of the leads if the resistors are temporarily moved. Make sure you position it back at the proper location prior to soldering however.

8.3. GLUE RESISTORS TO BACKS OF MID-BASS DRIVERS:

Follow the next steps to attach the resistors to the rear of the mid-bass drivers.

8.3.1. ☐ **Remove Tape from Rear of All Mid-Bass Drivers:**



Remove the electrical tape but be very cautious not to allow any trash to fall into the ND91 magnet hole.

 **FOR PROPER OPERATION OF THE MID-BASS DRIVERS, THE MAGNET HOLES MUST REMAIN OPEN.**

8.3.2. ☐ **Apply Glue to Magnet:**



Apply a small bead of hot glue to the magnet near the terminals.

8.3.3. ☐ **Glue Resistors to Rear of Mid-Bass Drivers:**



Glue the mid-bass resistors to the magnets of the ND-91 drivers and verify the resistor values:

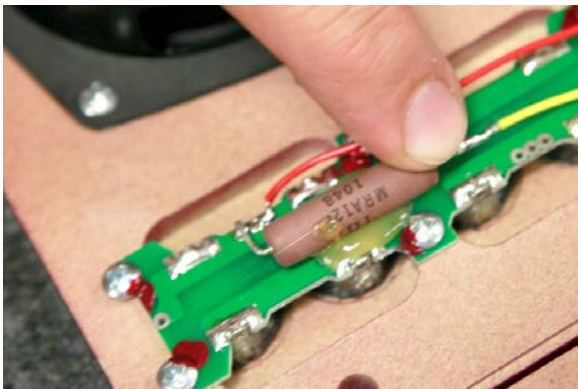
- 1) ☐ Driver 18 - 2.0 // 2.0
- 2) ☐ Driver 16 - 3.0 // 3.0
- 3) ☐ Driver 14 - 5.0 // 5.0
- 4) ☐ Driver 11 - 1.5 // 1.5

8.3.4. ☐ **Lift Resistors and Squirt Glue Underneath**



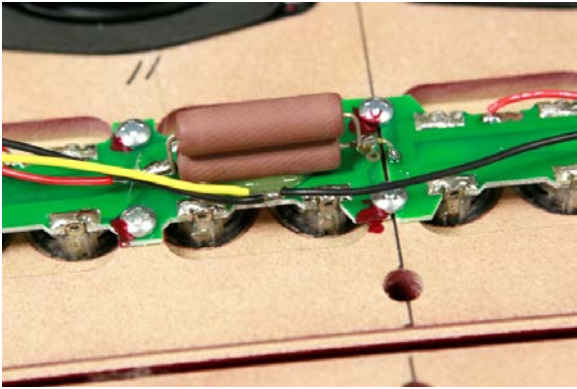
Lift the resistors soldered to the Tweeter PCB enough to squirt a small bead of glue underneath them.

8.3.5. ☐ **Press Resistor Down Until Glue is Set:**



Press the resistor down and hold till the glue cools.

8.3.6. ☐ Glue Tweeter Resistors to PC Board:

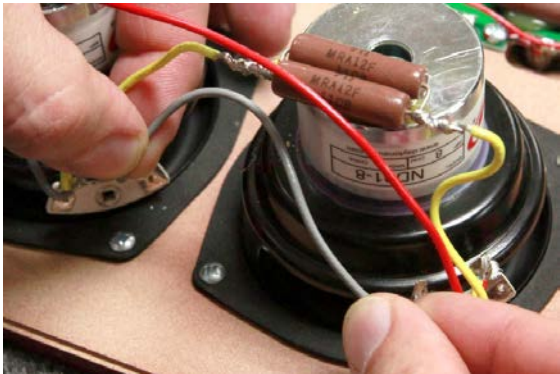


Glue the Tweeter Module resistors and, verify the resistor values:

- 1) ☐ PCB 18 - 1.0
- 2) ☐ PCB 16 - 1.5
- 3) ☐ PCB 14 - 2.5
- 4) ☐ PCB 11 - 1.5//1/5

8.4. DRESS WIRING FOR ND91 MID-BASS DRIVERS AND TWEETERS:

8.4.1. ☐ Bend the Jumpers:



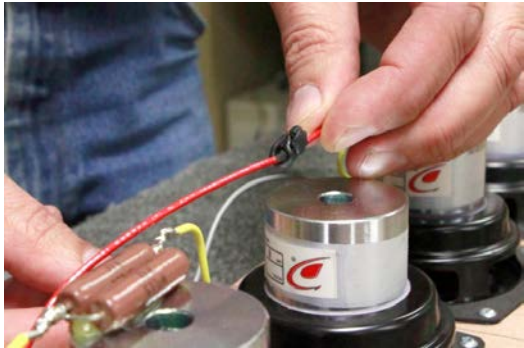
Bend jumpers so they curve in toward the drivers. Longer jumpers will route across the back of the magnets.

8.4.2. ☐ Unroll the Speaker Caulk:



Unroll the speaker caulk and pull off a 2 inch length.

8.4.3. ☐ Wrap the Caulk Around Jumper:



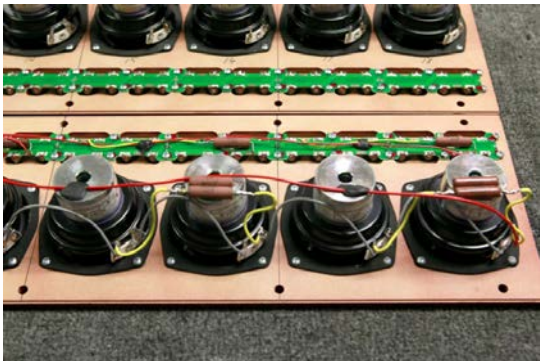
Wrap the caulk around the long jumpers as shown.

8.4.4. ☐ Press the Caulked Wire to the Magnet:



Press the caulk against the magnet and form a mound to hold the wire securely. Do not allow the caulk to enter the magnet hole.

8.4.5. ☐ Caulk the Rest of the Wires:



Work your way down the speaker caulking the wires to the back of each of the magnets. At locations with more than one wire, wrap the caulk around all before bonding to the magnet.

8.4.6. ☐ Hot Glue the Wires:



Hot glue the wires to driver 1 as shown. Repeat these steps for the tweeter wires. Be careful not to get hot glue on the rear surface of the mid bass cone.

9. TEST THE WIRING:

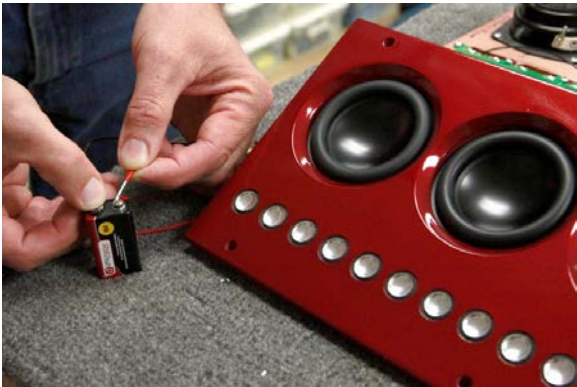
9.1. VERIFY CORRECT POLARITY OF DRIVERS MOUNTED TO FRONT PANEL:

9.1.1. ☐ Prepare to Test Polarity:



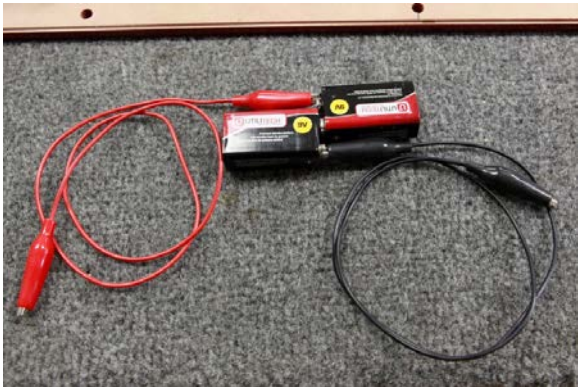
The wired panel on the right is ready for test. The RED and BLACK wires extending off of the bottom of the panel are the input to each group of drivers. The larger 18 AWG wire connects to the ND91s and the smaller 24 AWG to the tweeter modules.

9.1.2. ☐ Test Mid-Bass Polarity:



Flip the panel over and hold the BLACK 18 AWG lead to the (-) terminal of the 9v battery and tap the RED lead on the (+) terminal. The ND91 drivers will all jump forward if the speaker is properly wired. Watch each driver as you tap the RED lead to the battery and verify they all move forward. Also, you should notice that the amount of movement decreases as you move up towards the top of the speaker crossing the bank boundaries along the way.

9.1.3. ☐ Tweeter Test Requires More Voltage:



Now we will repeat the test for the tweeter array. In order to visually see the movement, we need a higher voltage drive level. We can get this by connecting two 9v batteries as shown. Connect the RED lead to the exposed (+) terminal and the BLACK lead to the exposed (-) terminal.



DO NOT ALLOW THE LEADS OF THE BATTERY TO TOUCH EACH OTHER, BECAUSE THE BATTERIES MAY OVERHEAT AND COULD POTENTIALLY CATCH ON FIRE.

9.1.4. ☐ Test Tweeter Polarity:



Connect the BLACK test lead to the BLACK 24 AWG input to the tweeter modules and tap the RED test lead to the RED 24 AWG input. Position your head so that you can sight down the speaker as shown above and you should be able to see each tweeter move forward. Tweeters in banks 4 and 5 will just barely move but look carefully and you will see the movement.

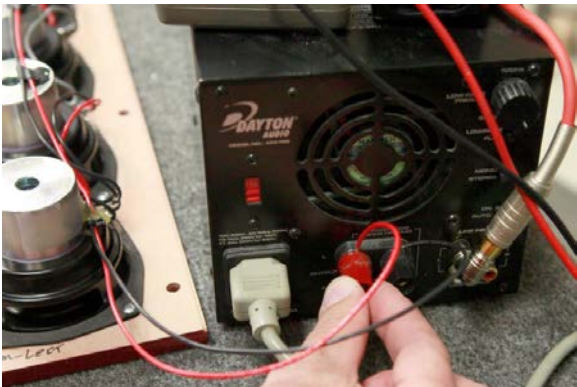
9.1.5. ☐ Troubleshooting Polarity Problems:

If you find any drivers that move inward you must correct this now, retrace the wiring for that driver and compare the wiring against the diagram and check for errors. If the drivers move inward, verify that you have the positive terminal of the battery connected to the positive (RED) input. Tweeter movement is very small and can be difficult to see in banks 4 and 5. You may need to view the speaker from the top for this test while someone taps the connection to the battery. Since we tested the individual tweeter modules earlier, we only need to verify that one in the group moves forward. Drivers that are wired in reverse are not harmed by the error but this error will significantly impair the polar behavior of the speaker and severely impact the uniform sound that the CBT is capable of delivering.

It's ok to connect the lead for a few seconds as you perform this test, however that battery life will be severely shortened, because it is delivering about 80 Watts of power. Due to the small size of the battery it can only deliver this power continuously for no more than about a minute.

9.2. VERIFY SHADING BANK ATTENUATIONS:

9.2.1. ☐ Connect Power Amplifier to Mid-Bass Drivers:



Flip the panel back onto its face and connect a power amplifier to the mid-bass drivers as shown.

NOTE: About Required Amplifier Power:
Any power amplifier rated at 10 watts or greater will work for this test. A volume control is handy but not totally necessary as long as you can control the output level of the source.

9.2.2. ☐ Connect Amplifier to Test Signal Source:



Connect the amp input to a 1 kHz sine wave from a convenient source. This might be a signal generator, CD player, iPod/smart phone or laptop. Adjust the volume till the output of the amplifier reads 3V -0/+0.05 on the DMM AC setting.



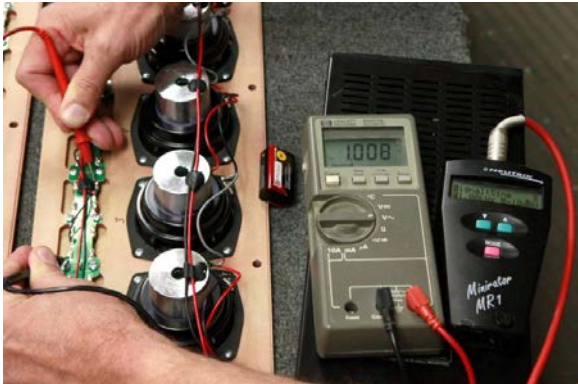
WEAR HEARING PROTECTION FOR THIS TEST!

9.2.3. ☐ Measure the Voltage Across Each Mid-Bass Driver:



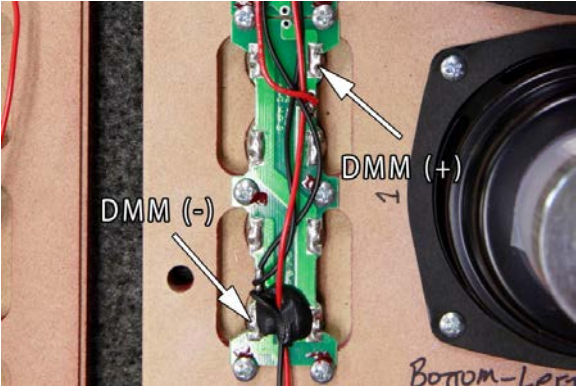
Measure the voltage across the terminals of each of the mid-bass drivers and record the results for all 18 drivers. Even though some drivers are in parallel it is still a good idea to check the voltage across each driver. Compare your results to the values listed in the table following the tweeter test.

9.2.4. ☐ Tweeter Bank Attenuations:



Disconnect the amplifier from the mid-bass drivers and connect it to the tweeters instead. Re-adjust the amplifier volume if necessary to maintain 3.0 V output. Measure the voltage across each tweeter module, **not an individual tweeter**, and record the voltage readings for all 18 modules. Compare your results to those shown in the next table.

9.2.5. Tweeter Module Voltage Probe Points:



Above is a close up of the probe points for the tweeter module. Start with tweeter module 1 and measure the voltage across all 18 modules by following the steps in the next subsection. Even though some modules are in parallel, it is a good idea to measure the voltage across each module.

9.2.6. Attenuation Voltage Level Table:

For a 3.0 Volt input the voltage reading for each bank should be:

- ☐ Bank 1: 1.00V +/- 0.1V (0 dB)
(Driver or Tweeter module 1, 2, 3, 4, 5, 6)
- ☐ Bank 2: 0.75V +/- 0.1V (-2.5 dB)
(Driver or Tweeter module 7, 8, 9, 10)
- ☐ Bank 3: 0.6V +/- 0.1V (-4.5 dB)
(Driver or Tweeter module 11, 12, 13, 14)
- ☐ Bank 4: 0.4V +/- 0.1V (-8.0 dB)
(Driver or Tweeter module 15, 16)
- ☐ Bank 5: 0.28V +/- 0.1V (-11.0 dB)
(Driver or Tweeter module 17, 18)

Retrace wiring and verify that the resistors are in the correct location if you find voltage errors.

10. ASSEMBLE THE CABINET:

10.1. INSTALL SPEAKON CONNECTOR ON REAR OF CABINET:

10.1.1. ☐ Install Connector:



Install the Speakon connector with wires attached on the rear of the cabinet. Orient as shown with the metal insert up. Install two #6 x 3/4 inch screws (Material List item 9).

10.2. INSTALL ACOUSTA-STUF

10.2.1. ☐ Load Acoustic Filler in Cabinet:



Fluff and evenly distribute one bag of Acousta-Stuf throughout the open chamber from top to bottom.

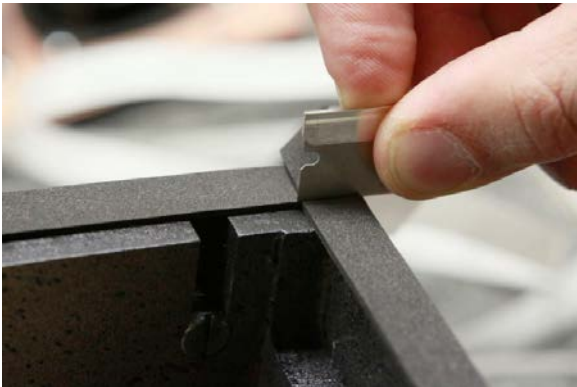
10.3. GASKET INSTALLATION

10.3.1. ☐ Trim Gaskets Flush at End of Cabinet:



Carefully trim the gasket flush with the end of the cabinet.

10.3.2. ☐ Trim Gaskets at Intersections:



Trim the gasket at intersections so the joints are tight.

10.3.3. ☐ Cut Gaskets at Slots



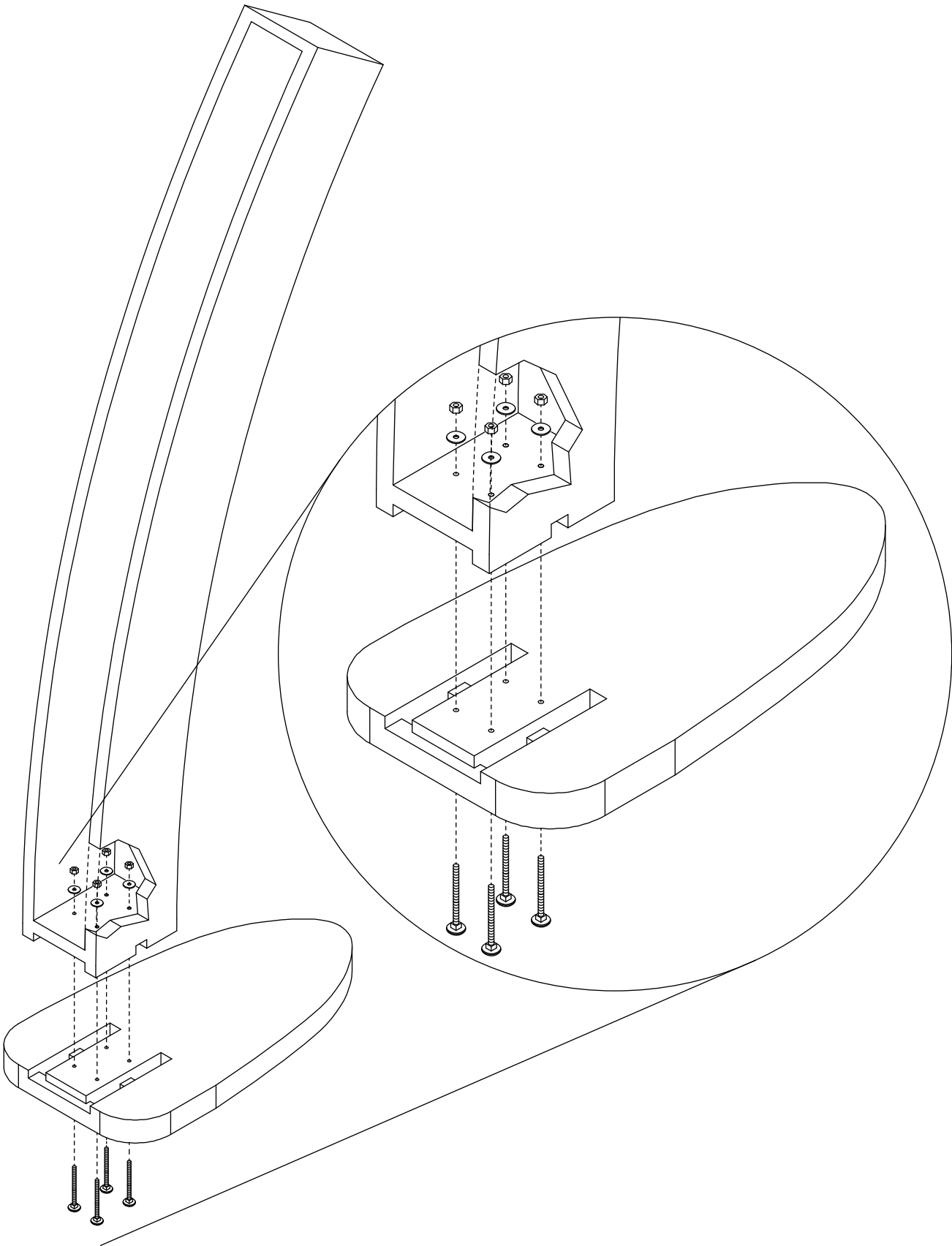
Cut the gasket in each screw slot and also at each slot at the end of the cabinet for both the mid-bass and tweeter compartments.

10.3.4. ☐ Push Gaskets into Slots and Glue to Side Walls:

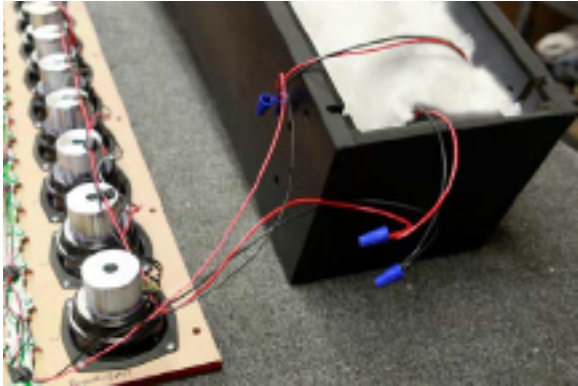


Push the gasket into the slots and press it against the side wall of the cabinet with the Allen tool so the self adhesive holds it in place.

10.4. Diagram of Base Assembly:



10.5. ☐ **CONNECT WIRES FROM MID-BASS AND TWEETER TO SPEAKON WIRES:**



Attach the 24 AWG wires from the tweeter line to the wires coming from the tweeter compartment in the cabinet using the wire nuts (item #31 in Material List). Next attach the 18 AWG wires from the mid-bass line to the wires from the mid-bass compartment of the cabinet.

10.6. ☐ **ATTACH FRONT PANEL TO CABINET:**



Align the front with the cabinet and position the bottom of the front panel and the bottom of the cabinet such that the front panel is about 1/32" shy of the end. Press the front down and partially tighten the first screw.

Install the screw directly across near the mid-bass driver and tighten it till the front panel is against the cabinet. Tighten the first screw about the same amount. Now work your way up the cabinet and install all screws. After all screws are installed, work your way around the cabinet tightening in a zigzag pattern. See the next page for troubleshooting screw installation problems.



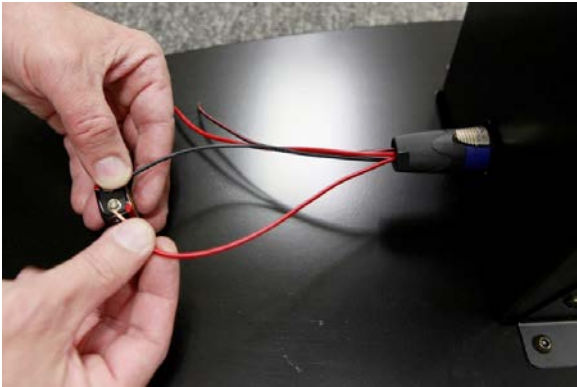
DO NOT OVER TIGHTEN SCREWS. VERIFY WIRING IS NOT PINCHED BETWEEN THE FRONT PANEL AND THE CABINET.

10.6.1. ☐ **Troubleshooting Front Panel Attachment:**

Each mounting hole location on the panel is optimized for a gasket compression of 40%, so when installing the panel on a fresh gasket the holes may appear to be off by a small amount. Installing the bolts from one end and working toward the other tends to minimize the error. The front panel screws occasionally cross thread. Sometimes the dowel nuts get contaminated with paint or dust. If the bolt gets hard to turn before it contacts the panel **DO NOT FORCE IT** to go further but rather back the bolt out and check the threads then try restarting the bolt again. If all attempts fail the quickest way to resolve this is to run a 1/4-20 tap into the threads to clear the obstacle.

11. MORE TESTING:

11.1. ☐ VERIFY SPEAKON WIRING:



Stand the speaker up on the floor and attach a speaker cable to the Speakon connector. Use a 9V battery and perform a polarity test on the mid-bass drivers by holding the BLACK (-) lead to the (-) terminal on the battery and the RED (+) lead to the (+) terminal on the battery. All mid bass drivers should jump forward. Repeat the test for the tweeters and verify they all move forward.

NOTE: For this test you will need a Speakon connector that is wired with four wires: 1(+) and 1(-) connected to the mid-bass drivers, and 2(+) and 2(-) connected to the tweeters; it is helpful at this point to label these so you can easily identify which pair goes to the mid-bass drivers and which pair goes to the tweeters.

(Refer to <http://www.n4tze.com/speakonconnectorwiring.pdf> for in-depth Speakon connecting information.)

11.2. RATTLE AND BUZZ TESTS:

In this test we are going to sweep a test tone to check for buzzes and rattles. This will verify that all the screws are tight and the front panel gasket is seated properly (See previous "AUDIO MEASUREMENT TOOLS" section for signal generator options). You can easily be fooled into thinking the speaker has a problem because many objects in a typical room can buzz. Also, if the CBT36 cabinet is setting on a hard surface, buzz and rattles can be originating there.

If you use the suggested PC "Audio SweepGen" signal generator, a suggested generator test setup is shown at the end of this section in subsection 10.2.3 "Generator Settings."

11.2.1. Mid-Bass Test:

- 1) ☐ We will start with the mid-bass drivers first, connect a signal generator to the input of a power amplifier and the output of the power amplifier to the mid-bass driver line.

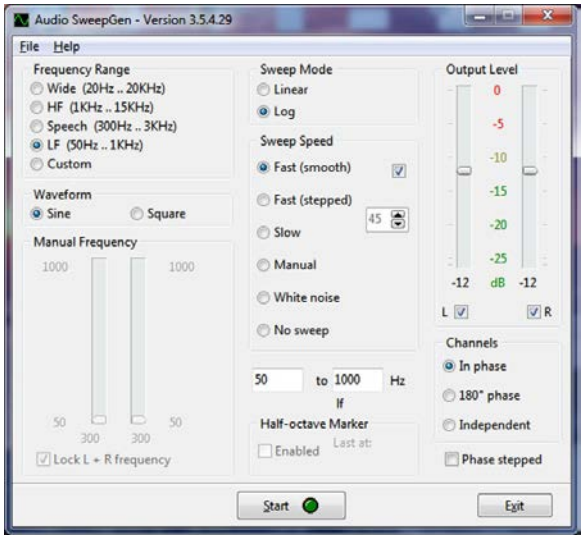
- 2) ☐ A DMM or AC voltmeter can be used to monitor the drive voltage to the speaker.
- 3) ☐ Adjust the amplifier to a low setting and start a sine wave sweep from 50 Hz to 1000 Hz, either manually or automatically as shown in the "Generator Settings" section that follows.
- 4) ☐ Increase the volume to a comfortable level and listen for buzz or rattles in the cabinet.
- 5) ☐ If the tone is pure and clear then increase the level till it is loud and continue to monitor the sound for any buzzes or rattles. (Both mid-bass and tweeter inputs of the system can easily handle long-term continuous levels up to 15 Vrms.)
- 6) ☐ If something sounds suspicious, then switch to manual mode if you are not there already, and adjust the frequency up and down slowly till the buzz becomes most noticeable. Move your ear up and down the cabinet to pinpoint to location. Check for any loose screws or components causing the buzz and tighten as necessary.

11.2.2. ☐ Tweeter Test:

Once you are satisfied that everything is OK with the mid-bass drivers, then repeat the test with the amplifier connected to the tweeter line. First lower the level before connecting to the tweeter, and set the generator to a 1000 Hz to 15 kHz sweep and then repeat the previous steps with the tweeters.

11.2.3. Generator Settings:

The following image shows the front-panel settings for the PC “Audio SweepGen” signal generator for the 50 Hz to 1 kHz sweep (refer to the previous “Audio Measurement Tools” section for more information on this generator). Either a “Fast (smooth)” or “Slow” Sweep Mode setting can be used.



11.3. CONGRATULATIONS, THE
ASSEMBLY OF THE CBT36K IS
COMPLETE!!!!

12. CROSSOVER SETUP:

INTRODUCTION:

This section describes setup of the recommended Behringer DCX2496 DSP Crossover which is sold by Parts Express (<http://www.parts-express.com/pe/showdetl.cfm?partnumber=248-669>, about \$250).

Other DSP processors may be used. We have experience with two other units: the DEQX HDP-EXPRESS (<http://www.deqx.com/>, about \$2,000), and the miniDSP 2x4 DSP processor (<http://www.minidsp.com/>, about \$125).

Here is an interesting diyAudio forum comparison of the three units (<http://www.diyaudio.com/forums/minidsp/176544-minidsp-vs-dcx2496-vs-dcx2496-modded-vs-deqx.html>). Dayton Audio bears no responsibility for the opinions expressed in these forum posts.

Refer to the “Crossover Filter/EQ Settings Table” in section 12.3 on pages 81 and 82 for help in setting these units.

12.1. SETUP OF BEHRINGER DCX2496 ULTRADRIVE PRO DSP CROSSOVER:

The primary function of a crossover is to divide the frequency spectrum into bands and route these bands to the driver(s) within the loudspeaker optimized to reproduce those frequencies. In addition, modern crossovers equalize response irregularities in each of the bands to better approximate an ideal speaker.



Fig. 18. Front panel of Behringer DCX2496 Ultradrive Pro DSP crossover.

The Behringer DCX2496 is a very versatile crossover based on Digital Signal Processing (DSP) that has 3 input channels and 6 output channels and may be configured to divide the spectrum in many different ways. For instance you can configure it to drive three 2-way speakers, or two 3-way speakers or two 2-way speakers plus a subwoofer.

A table at the end of this section has a complete list of all the crossover filter and equalization settings that are required for the CBT36. This table can be used as a starting-off place if you desire to use another DSP crossover other than the ones we recommend. Remember however, you are on your own here!

12.1.1. Simplified CBT36 Crossover Signal Flow:

CBT36 is designed to be a two-way speaker, meaning that the spectrum is divided into two bands, one for the mid-bass drivers and one for the tweeter drivers, the remaining two output channels can send the low frequencies to an optional subwoofer amplifier. Initially the crossover is set up so that CBT36 can be used without a subwoofer but with only simple changes you can add a subwoofer of your choice and mate it with CBT36.

The following figure shows a typical signal-flow setup when an optional subwoofer is used. The frequency response transfer-function curves in the boxes are the actual curves used in this setup, not dummy data. The first block in the diagram contains the lift compensation that equalizes the power rolloff of the CBT36 (for an explanation of this power rolloff refer to the section “CBT36 Power Rolloff” later in APPENDIX 2: “CBT THEORY OF OPERATION”). The compensation starts at 200 Hz and then rises at 3 dB/octave (10 dB/decade) up to 20 kHz. This EQ equalizes the axial and power frequency responses of the CBT36 to be flat to 20 kHz. Refer to the section “The Flat Energy Response Debate” later in APPENDIX 2 for more information on this equalization and it’s effects. See also section titled “Check your Crossover Work” later in this section for overall crossover transfer-function curves.

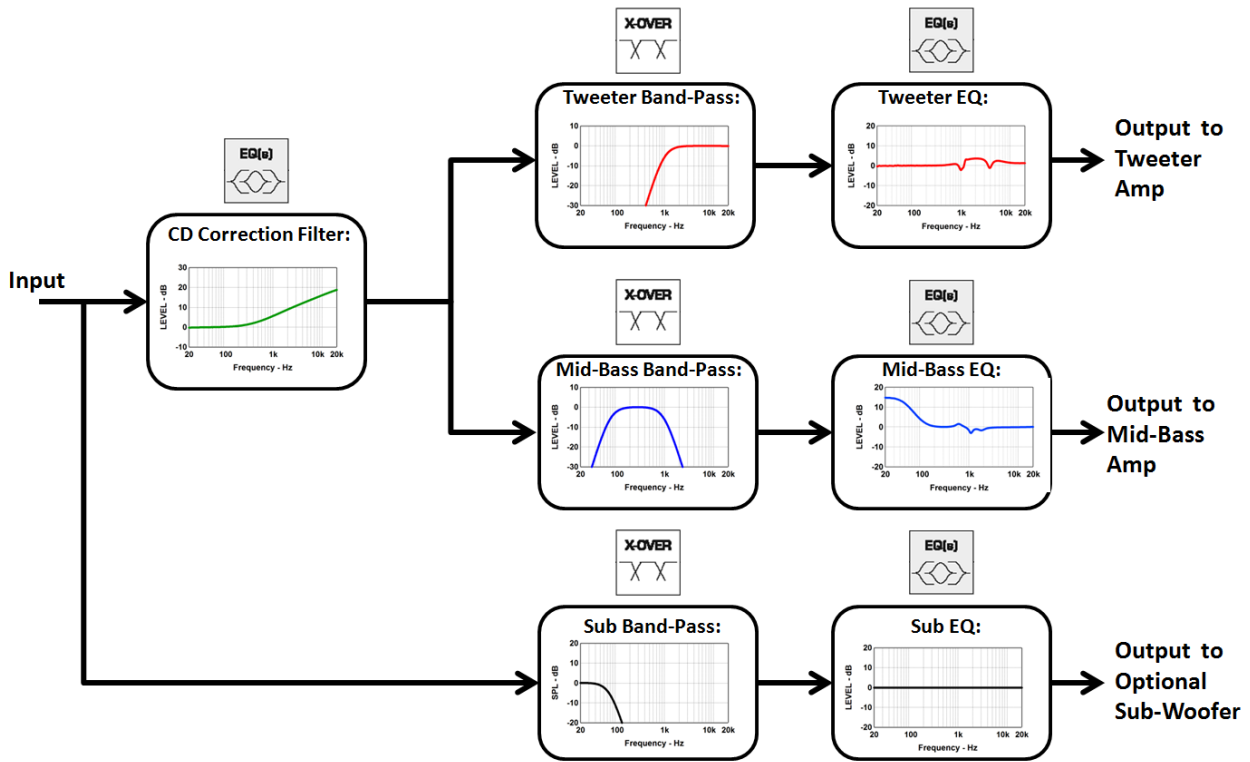


Fig. 19. Simplified signal flow for CBT36 active crossover setup for flat axial and energy response with optional subwoofer. The first signal block (left) contains the constant-directivity (CD) power correction equalization that compensates for the power rolloff of the CBT36 (+3 dB/octave starting at 200 Hz). Each block shows actual crossover transfer-function response curves used in the DCX2496. Actual levels in the DCX2496 crossover are not preserved in the above graphs. Actual levels are adjusted to maximize crossover headroom.

12.1.2. DCX2496 Crossover Filter Types:

The DCX2496 has the capability to provide the following three crossover types at arbitrary corner frequencies:

- 1. Butterworth high-pass and low-pass filters with slopes of 6, 12, 18, 24, or 48 dB/octave.
- 2. Bessel high-pass and low-pass filters with slopes of 12 or 24 dB/octave.
- 3. Linkwitz-Riley high-pass and low-pass filters with slopes of 12, 24, or 48 dB/octave.

There are many popular filter types that can be used to divide the spectrum into bands and each has desirable merits in certain applications. CBT36 works best with the Linkwitz-Riley filters and in particular a 24dB/octave version of the filter. Crossover choice is complex and beyond the scope of this manual and even though other filter types might work, we cannot guarantee the performance of CBT36 if you choose a different crossover filter.

Here are examples of filters in the following listing: [TYPE: BUT24] [FREQ: 20Hz] means a Butterworth high-pass filter at 20 Hz with a slope of 24 dB/octave.

[TYPE: L-R24] [FREQ: 1.00kHz] means a Linkwitz-Riley low-pass filter at 1.0 kHz with a slope of 24 dB/octave.

12.1.3. DCX2496 Equalization (EQ) Filter Types:

To operate correctly, the crossover filter shapes mentioned in the previous section must apply to **the measured acoustic frequency responses of the drivers**, not to just the crossover's electrical signal sent to the drivers. If the driver's acoustic response deviates significantly from a perfectly-flat frequency response in the crossover's overlap range, the crossover will not sum properly.

To achieve this desired flatness, the electrical drive signal must be altered to compensate for non-perfect acoustic responses of the drivers. This is the primary purpose of the EQ section in a DSP crossover.

In addition, some DSP crossovers include filters that can be used to correct room problems, but these crossovers with this feature usually come at a higher cost and are not covered here.

The DCX2496 can provide three different EQ filter types:

- 1. Low-Shelf (boost or cut) with slopes of 6 or 12 dB/octave at an arbitrary frequency. *Behringer calls this a "low-pass filter".*

Example in the following listing: [TYPE: LP] [FREQ: 805Hz] [GAIN: -3.0dB] [>6dB] means a 6 dB/octave low-shelf filter at 805 Hz with a cut of 3.0 dB.

- 2. High-Shelf (boost or cut) with slopes of 6 or 12 dB/octave at an arbitrary frequency. *Behringer calls this a “high-pass filter”.*

Example in the following listing: [TYPE: HP] [FREQ: 6.43 kHz] [GAIN: 3.0dB] [>6dB] means a 6 dB/octave high-shelf filter at 6.43kHz with a boost of 3.0 dB.

- 3. Parametric EQ (boost or cut) with arbitrary center frequency and Q. *Behringer calls this a “band-pass filter”.*

Example in the following listing: [TYPE: BP] [FREQ: 238Hz] [GAIN: -3dB] [Q10] means a parametric filter with a dip of 3 dB at 238 Hz with a Q of 10.

12.1.4. Example Shelf and Parametric Filter Frequency Responses:

12.1.4.1. Shelf Filters:

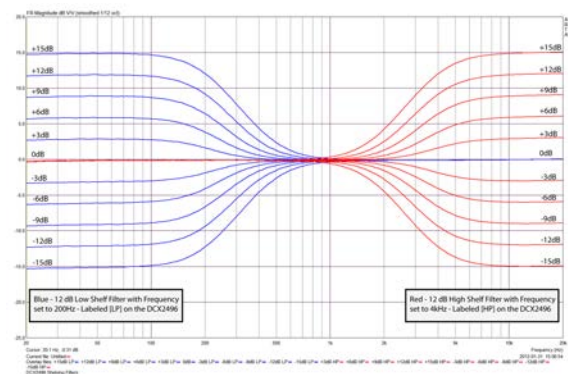


Fig. 20. Example frequency responses of the 12 dB/octave 200 Hz low-shelf (blue) and 12 dB/octave 4 kHz high-shelf (red) shelving filters implemented by the DCX2496 crossover. Boosts and cuts in the range of ±15 dB are illustrated with 3 dB steps. Behringer calls these respectively low-pass (LP) and high-pass (HP) filters.

12.1.4.2. Parametric (Peak-Dip) Filters:

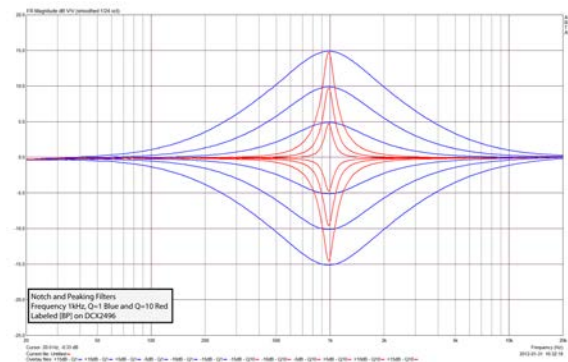


Fig. 21. Example frequency responses of the parametric equalizer implemented by the DCX2496 crossover with two Q values: Q = 1 (blue), and Q = 10 (red). A filter center frequency of 1 kHz is illustrated with boosts and cuts in the range of ±15 dB with 5 dB steps. Behringer calls these band-pass (BP) filters.

12.1.5. Crossover Frequencies and Addition of Woofers:

The crossover between the mid-bass drivers and the tweeter modules is 1 KHz, and without a subwoofer, the mid-bass drivers gradually stop working below 45Hz. If you add a subwoofer you can choose the crossover frequency but a good starting point is 80 Hz which means the subwoofer will reproduce frequencies below 80 Hz and relieve the mid-bass drivers in CBT36 of this burden. This will allow better reproduction of instruments that can produce very low notes such as bass clarinet and pipe organs and allow the greater overall volume level.

12.1.6. DSP Crossover Architecture:

The Behringer DCX2496 architecture is broken down into sections and some sections are not necessary for CBT36. The sections we will use are Input EQ, Routing, Gain, X-over Filters, Output EQ, Sum, and Short/Long Delay. Limiters and dynamic EQ are useful if you intend to use the speaker for PA applications but are generally not recommended for the audiophile. Refer to our website for additional details and proper limiter/dynamic EQ settings.

12.1.7. Three Ways to Load Settings into the Crossover:

Crossover settings can be loaded in three different ways:

- 1) a compact flash memory card loaded into PCMCIA adapter plugged into the front panel of the DCX2496,
- 2) a connection to a PC laptop via a USB to RS232 adapter, or
- 3) manually from the front panel user interface of the DCX2496.

The most convenient way is to use the compact flash card, but the PC connection, while tricky to set up has the advantage of allowing quick changes in case you wish to tweak the crossover EQ for your environment.

Manual entry from the front panel is tedious but you can enter all the settings once you understand how to navigate through the menus of the DCX2496. The detailed steps for manual entry are covered later in several sections.

12.1.8. Load Settings Via a Compact Flash Card Plugged into PCMCIA Adapter Connected to PC Computer:

The preferred method of loading the crossover settings is via a compact flash card, it does not need to have large memory capacity, 8 Mbyte is more than enough. Download the latest crossover settings from <http://www.parts-express.com/cbt36k-line-array-speaker-pair-kit--301-980> and save them on the compact flash card.

Insert the compact flash card into the PCMCIA adapter and insert the PCMCIA adapter into the crossover (slot on the front of the DCX2496).

The following photo shows a compact flash PC card adapter along with an 8 Mbyte compact flash card.



Press [RECALL] [PARAM] rotate [KNOB] if necessary to select [CARD: 1 CBT36FLT] [OK]. Other choices may also be selected if you prefer a warmer or less-bright sound. Or wish to add a subwoofer, etc.

Now proceed to section 12.2 “Connect the Behringer DCX2496 Crossover to the System” and also refer to section 13.2 “System Connections: Example.....” to connect the crossover to the amplifiers.

12.1.9. Load Settings Via a RS-232 Serial Connection to PC Computer:

RS232 is not commonly included on modern PC's, especially laptops but you can purchase a USB adapter that provides a standard RS232 port (not a NULL modem port) that will work with the DCX2496. The connector on the rear of the DCX2496 is a female therefore you will need a male connector on the RS232 cable.

12.1.9.1. Download DCX2496 Editor Software:

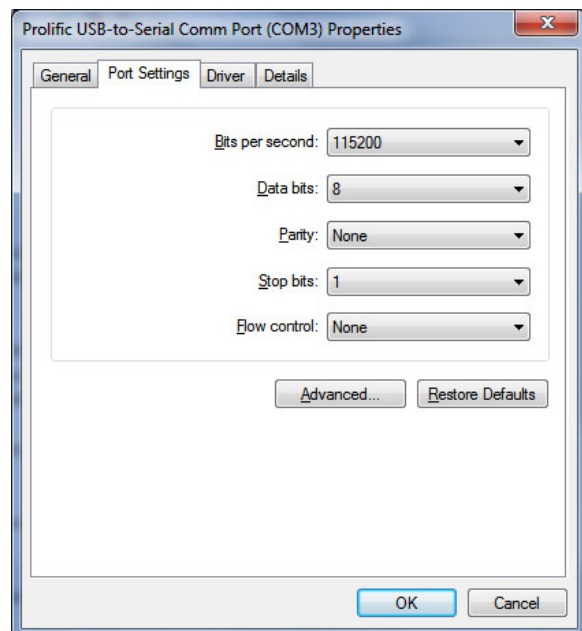
Download the Editor Software for the DCX2496 (**v 1.16a or greater**) from the Behringer web site (link shown below) and install it on the PC you intend to use to setup your crossover, also install the RS232 interface and any drivers needed for the USB adapter.

<http://www.behringer.com/EN/Products/DCX2496.aspx>

12.1.9.2. Configure RS232 Serial Communications Channel:

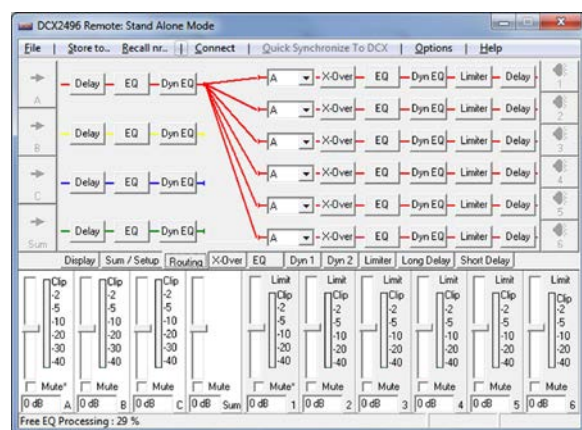
Navigate to setup page 5 of 5 on the DCX2496 and make sure that port is set to PC (RS232). Press [SETUP] [<PAGE] and use the [PARAM-] to highlight the PORT: field. Rotate the knob till the field is set to PC (RS232).

The RS232 specification does not have provisions for automatically setting up the communication channel so you will need to manually set the data rate and handshaking of the PC's COMx (where x will be 1, 2, or 3) port. Navigate to the Windows device manager and set all the fields so they match the ones shown in the following figure. This example is for Windows 7 but the screen looks very similar in Vista and Windows XP.

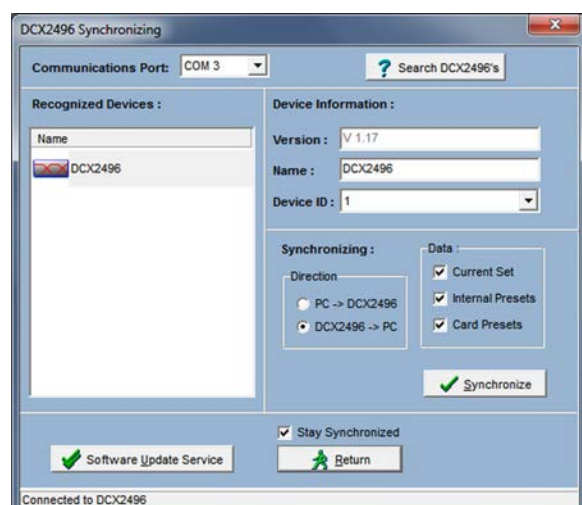


12.1.9.3. Connect RS232 Cable and Test Connection:

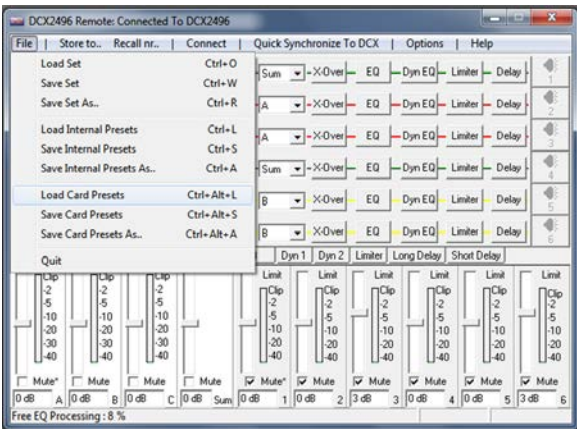
Connect the RS232 cable to the crossover and start the editor software. Select the [Connect Tab] near the top of the DCX2496 editor software window (which follows).



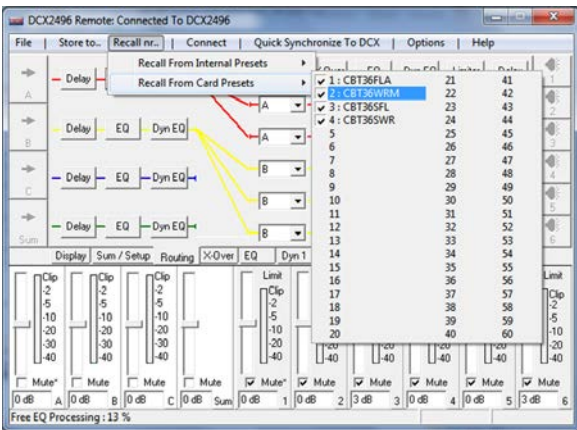
If you connect successfully you should see a window like the one in the following figure. If it fails to connect select retry, if it still does not connect you will need to troubleshoot the RS232 connection. Sometimes this means a trial and error approach till you get it working. This is what we meant when we mentioned that setting up RS232 can be tricky! Set the direction to PC -> DCX2496 and data to current set.



Download the DCX2496 setup file from <http://www.parts-express.com/cbt36k-line-array-speaker-pair-kit--301-980> and load it into the editor by choosing [FILE] [LOAD CARD PRESETS]



Now recall one of the crossover setups.



The crossover's "live" settings will be set up according to the choice you made. It is a good idea to store this setting to one of the internal memories in the crossover. Press [STORE] and select an internal [INT] memory location by using the [PARAM>] key and [KNOB]. Enter the characters for the name but rotating the [KNOB] in the [NAME] field.

Now proceed to section 12.2 "Connect the Behringer DCX2496 Crossover to the System" and also refer to section 13.2 "System Connections: Example....." to connect the crossover to the amplifiers.

12.1.10. Load Settings Via Manual Entry with Knobs on Front of DCX2496:

Manual entry is not difficult, but it is very tedious and requires that you become familiar with the menus of the DCX2496. Refer to the DCX2496 manual for details on the user interface.

12.1.10.1. DCX2496 User Interface Overview:

The front panel photo shown previously in Fig. 17 (repeated here for easy access) shows the input and output channels.



On the far left are the input keys, these inputs are identified as A, B and C but may be labeled with more meaningful names such as LEFT or RIGHT. When you press one of the input keys the display will show 1 of 5 possible pages, you can cycle through all of these pages by pressing either the [<PAGE] or [PAGE>].

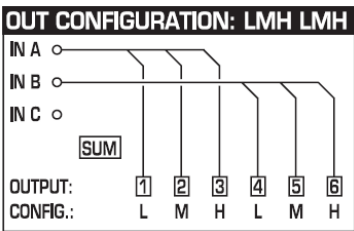
Once you move to the page that requires modification you will use the [<PARAM] or [PARAM>] to move between input fields on that page (some pages only have one input field and in this case the [PARAM] key is inactive). After you navigate to the page and the field that requires change, you will rotate the knob to select the value needed.

Output channels are identified as 1, 2, 3, 4, 5, and 6 but each channel can be labeled with a more meaningful name such as SUB, MID and HIGH. When you press one of the output keys the display will show 1 of 8 possible pages. Navigation to a specific field is accomplished the same way as for the input channels using the [PAGE], [PARAM] and [KNOB].

Other keys you will need are [MUTE] [RECALL] [SETUP] [SUM], you can explore the other functions after the speaker is up and playing. The [COMPARE] feature is very handy for comparing two different settings on the crossover. [MUTE] allows you to mute the output of any channel or any combination of channels. Press [MUTE] followed by the channel you wish to enable or disable.

12.1.10.2. Manual Crossover Setup Steps

We will set up each section step by step to help you minimize entry errors. First, we need to set the DCX2496 to a known state by resetting it to its factory condition. This will automatically load preset one which is a stereo-in three-channel-out configuration (called LMH LMH by Behringer). This is shown in the following diagram from Behringer's DCX2496 manual.



This preset links both stereo channels to allow parameters to be entered in one channel only rather than twice in both left and right channels.

Follow the sequence that follows and the crossover will be ready to use once you complete all the steps.

12.1.10.3. Step One, Set the Crossover to a Known State; Reset to Factory Condition:

☐ In this step we are going to set the crossover to a known state by restoring the DCX2496 to its "shipped-from-the-factory" state with all factory presets restored and all edited or entered user presets erased.

If you're working with a new DCX2496 for the first time, you won't have to worry about erasing any of your presets. If your unit is not new and/or you have used it before, you will have to either store your presets on a compact flash card or on your computer via a RS232 serial connection before resetting.

Of course, you can continue with the following steps without restoring the crossover to its factory state but some of the following steps may not apply exactly. What does count in this case however is that the appropriate parameter values themselves get entered correctly in the proper locations. In this situation, presumably you are experienced with operating the DCX2496 and may not require as much handholding.

The DCX2496 is reset to its factory condition by **turning it on while simultaneous pushing and holding both PAGE buttons on the front panel.** This will immediately invoke a confirmation warning on the front panel to either accept or reject the reset. To reset the crossover, press OK.

Note that this reset operation automatically loads factory preset number one which initializes the crossover to a stereo three-way configuration with both stereo channels linked together. This means that you only need to enter the parameters in one channel and the data is replicated in the other channel.

Also note that loading this preset mutes all outputs. After all the following data entry steps are accomplished, the last step will instruct you to un-mute all outputs (including the sub channels whether their active or not) in preparation for connecting the crossover in your system. In the final system check phase, the output mutes can be used selectively to easily check proper operation of each mid and tweeter channel.

Note to experienced users: If you didn't reset the crossover as instructed above, preset one must be loaded first before the next steps are accomplished (assuming you didn't modify it before).

12.1.10.4. Step Two, Turn on INPUT "A" EQ:

The following step turns on the equalization (EQ) for the left channel input "A". Due to the linking, this also turns the EQ on for the right channel input "B." Remember that the third input "C" is not used.

☐ Navigate to input A, page 3 of 5 - Press [INPUT A] [PAGE>] [PAGE>] and use the knob to turn the [EQ:ON].

The following photo shows the DCX2496 front panel display after the EQ is turned on:



For the next several entries you will use a combination of the [PARAM] key and the Knob to change [NR] [TYPE] [FREQ] [GAIN] [> xxdB] etc. The [PARAM] key cycles through each of the input fields looping back to the beginning when you reach the last entry. [PARAM>] moves

the cursor to the right and [<PARAM] moves the cursor to the left. The short hand notation "NR" means number and preceeds the number of the filter in this input channel.

12.1.10.5. Step Three, Enter the 3dB/octave CD Correction Filter:

See Appendix 2: "Theory of Operation" section 14.2.13 for an explanation of why this filter is necessary. Some may prefer a slight downward tilt in the frequency response because the sound may be perceived to be too bright, particularly in live environments. This is easily accomplished by replacing all instances of "3.0" dB with either "2.0" dB or "2.5" dB in filter numbers 1 to 7 ([NR: 1 through NR: 7]), i.e. -3.0 dB turns into -2.0 dB (or -2.5 dB) and +3.0 dB turns into +2.0 dB (or +2.5 dB), etc. (See section 14.2.13.7)

The following steps setup the EQ for the seven input filters for both channels:

☐ [NR: 1] [TYPE: LP] [FREQ: 401Hz] [GAIN: -3.0dB] [>6dB]

☐ [NR: 2] [TYPE: LP] [FREQ: 805Hz] [GAIN: -3.0dB] [>6dB]

☐ [NR: 3] [TYPE: HP] [FREQ: 1.60kHz] [GAIN: 3.0dB] [>6dB]

☐ [NR: 4] [TYPE: HP] [FREQ: 3.24kHz] [GAIN: 3.0dB] [>6dB]

☐ [NR: 5] [TYPE: HP] [FREQ: 6.43kHz] [GAIN: 3.0dB] [>6dB]

☐ [NR: 6] [TYPE: HP] [FREQ: 12.8kHz] [GAIN: 3.0dB] [>6dB]

☐ [NR: 7] [TYPE: HP] [FREQ: 20.0kHz] [GAIN: 3.0dB] [>6dB]

After you enter the seventh EQ filter (NR: 7), the screen will look like the following photo.



12.1.10.6. Step Four, Set Up the Mid-Bass Channel:

The following steps set up the crossover filter type and frequency for the mid-bass channel on output two (and with linking channel five).

☐ Press [OUTPUT 2] [PAGE>]

☐ Set the high-pass filter parameters to: [TYPE: BUT24] [FREQ: 20Hz].

☐ Set the low-pass filter parameters to: [TYPE: L-R24] [FREQ: 1.00kHz].

The next photo shows the display after this information has been entered.



12.1.10.7. Step Five, Set Up the Mid-Bass EQ:

The next five steps set the EQ for the mid-bass channel on output two. This is found on page 3 of 8 of channel two's output menu.

- ☐ Press [PAGE>] [EQ: ON]
- ☐ [NR: 1] [TYPE: LP] [FREQ: 50Hz] [GAIN: +15.0dB] [>12dB]
- ☐ [NR: 2] [TYPE: BP] [FREQ: 620Hz] [GAIN: +1.8dB] [Q 2.8]
- ☐ [NR: 3] [TYPE: BP] [FREQ: 1.09kHz] [GAIN: -3dB] [Q 5.6]
- ☐ [NR: 4] [TYPE: BP] [FREQ: 1.78kHz] [GAIN: -1.5dB] [Q 2.8]

The following photo shows the display after these steps are completed.



12.1.10.8. Step Six, Set Up the Tweeter Channel:

These steps set up the tweeter channel crossover filters on output three (and with linking channel six). This is found on page 2 of 8 of output three's setup menu.

- ☐ Press [OUTPUT 3] [<PAGE]
- ☐ Set the high pass filter parameters to [TYPE: L-R24] [FREQ: 1.00kHz].
- ☐ Set the low pass filter parameters to [TYPE: OFF].

The next photo shows the front-panel display after these steps are completed.



12.1.10.9. Step Seven, Set Up Tweeter EQ:

The following six steps set up the tweeter EQ on output three, which is found on page 3 of 8:

- ☐ Press [PAGE>] [EQ: ON] and enter the following parameters:
- ☐ [NR:1] [TYPE: BP] [FREQ: 1.00kHz] [GAIN: -4.5dB] [Q: 6.3]
- ☐ [NR:2] [TYPE: HP] [FREQ: 1.00kHz] [GAIN: +4.0dB] [>12dB]
- ☐ [NR:3] [TYPE: BP] [FREQ: 1.14kHz] [GAIN: -2.4dB] [Q: 10]
- ☐ [NR:4] [TYPE: BP] [FREQ: 1.24kHz] [GAIN: +1.5dB] [Q: 10]
- ☐ [NR: 5] [TYPE: BP] [FREQ: 3.85kHz] [GAIN: -5.0dB] [Q: 5]
- ☐ [NR:6] [TYPE: HP] [FREQ: 7.01kHz] [GAIN: -3.0dB] [>12dB]

The following photo shows the front-panel display after these seven steps are completed.



12.1.10.10. Step Eight, Set Up Tweeter Time Delay:

The next two steps set the tweeter time delay on output three. This is found on page 8 of 8.

- ☐ Press [Page>] [Page>] [Page>] [Page>] [Page>]
- ☐ Set [DLY: ON] [SHORT: 60mm]

After entering these steps the front-panel display appears as follows:

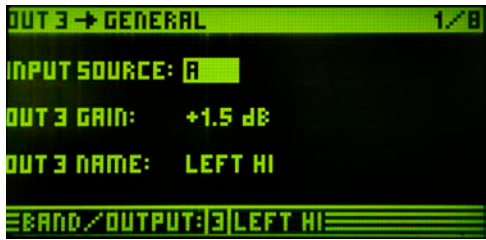


12.1.10.11. Step Nine: Set Tweeter Level:

The following two steps set the tweeter level on output three. This is found on page 1 of 8.

- ☐ Press [Page>]
- ☐ Set OUT 3 GAIN: to [+1.5dB]

After these steps are completed the display appears as:



12.1.10.12. Subwoofer Setup:

The steps in the following four sections set up the optional subwoofer channel in outputs one and four. This provides a summed signal in both outputs to drive one or two mono subwoofers. For a setup for two independent stereo subs, refer to our website. *(Skip the next four sections if you are not using a subwoofer.)*

12.1.10.13. Step Ten: Select SUM Signal to Drive a Mono Subwoofer.

The next step forms a sum signal from inputs “A” and “B” to drive the subwoofer. This is found on page 1 of 5 of the SUM menu.

- ☐ Press [SUM] and turn [KNOB] to select [A+B]

The front-panel display will then show:



12.1.10.14. Step Eleven, Select Sum as Source for Subwoofer Outputs:

The next two steps connect outputs one and four to the input's sum signal to be used as a source for the subwoofer. This is found on page 1 of 8 of the menus for outputs one and four.

- ☐ Press [OUTPUT 1] and turn [KNOB] to select [SUM]
- ☐ Press [OUTPUT 4] and turn [KNOB] to select [SUM]

After these two steps, the following photo shows the display for output one. Not shown is the corresponding photo for output four.



12.1.10.15. Step Twelve, Set Up Subwoofer Filter:

Set the subwoofer low-pass filter crossover frequency and filter type for both sub outputs.

- ☐ Press [PAGE>] and set low-pass filter to TYPE: [L-R24] FREQ: [80Hz]

- ☐ Press [OUTPUT 4] [PAGE>] and set low-pass filter to TYPE: [L-R24] FREQ: [80Hz]

After these two steps, the following photo shows the display for output one. Not shown is the corresponding photo for output four.



12.1.10.16. Step Thirteen, Set Up Mid-Bass Filters:

The following step configures the mid-bass high-pass filters for use with the subwoofer(s). This is accomplished by moving the crossover frequency for the mid-bass high-pass filters up to the same frequency as the subwoofer low-pass filter and changing the filter type to L-R24. **NOTE:** Linking still operates for these outputs so there is no need to explicitly set output five.

- ☐ Press [OUTPUT 2] [PAGE>] and set the high-pass filter on page 2 of 8 to TYPE: [L-R24] and FREQ: [80Hz]

The next photo shows the display after this step.



12.1.10.17. Step Fourteen: Un-mute all Crossover Outputs:

- ☐ Press [OUTPUT 3] to return to the main menu.
- ☐ Press [MUTE] [OUTPUT 1] [OUTPUT 2] [OUTPUT 3] [OUTPUT 4] [OUTPUT 5] [OUTPUT 6] [MUTE]

12.1.11. Check Your Crossover Work:

The ambitious DIY speaker builder can check their work by measuring the crossover transfer functions. See the Measurement section in this manual for tools that can make this measurement. ARTA is a tool that will allow you to make these measurements in demo mode. Follow the setup in the ARTA manual and measure the crossover and compare your results with the following figures.

This section shows two sets of crossover curves with the crossover set to the “Flat-Mode” setting and the “Rolled-Off-Mode” setting (a rolloff of 1 dB/octave or 3.3 dB/decade above 200 Hz). See section titled “The Flat Energy-Response Debate” in Appendix 2 for an explanation of the need for these two different response settings.

Each set shows the actual crossover transfer function curves along with the resultant CBT36 frequency response curves (measured at 2 m from the base of the system at 1 m high). The two sets illustrate the response for the flat-mode setting and the rolled-off mode setting (1 dB/octave or 3.3 dB/decade).

12.1.11.1. Crossover Transfer Functions in Flat Mode:

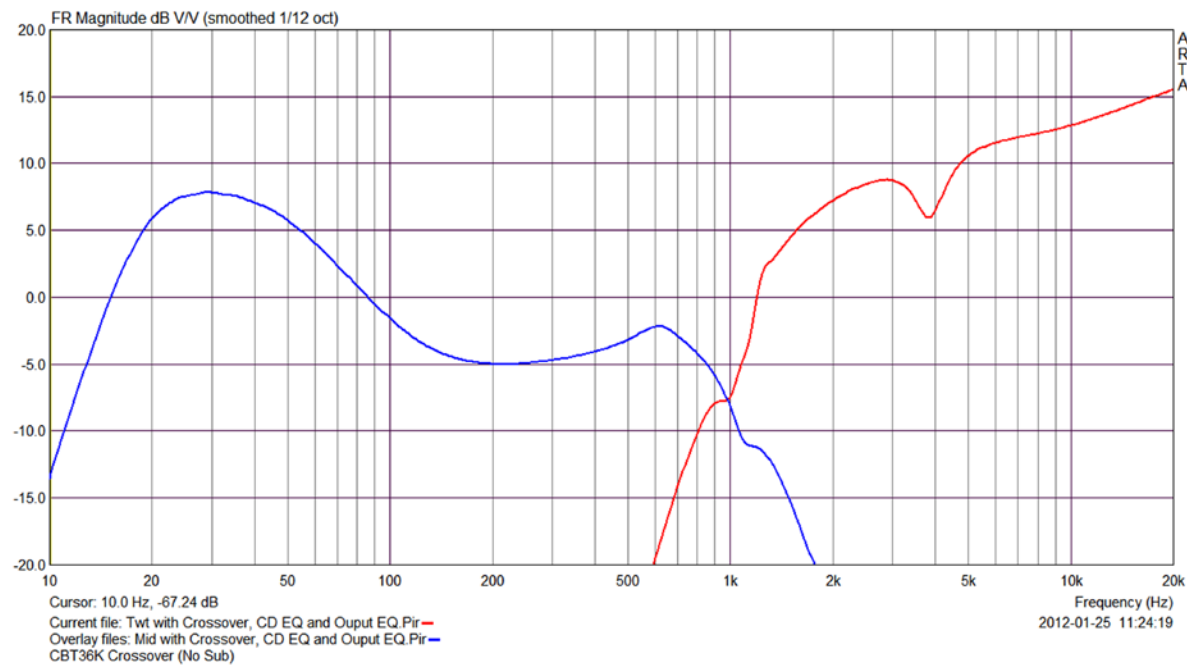


Fig. 22. Flat mode DCX2496 crossover transfer functions (LF: blue, HF: red).

12.1.11.2. Resultant CBT36 System Frequency Responses in Flat Mode:

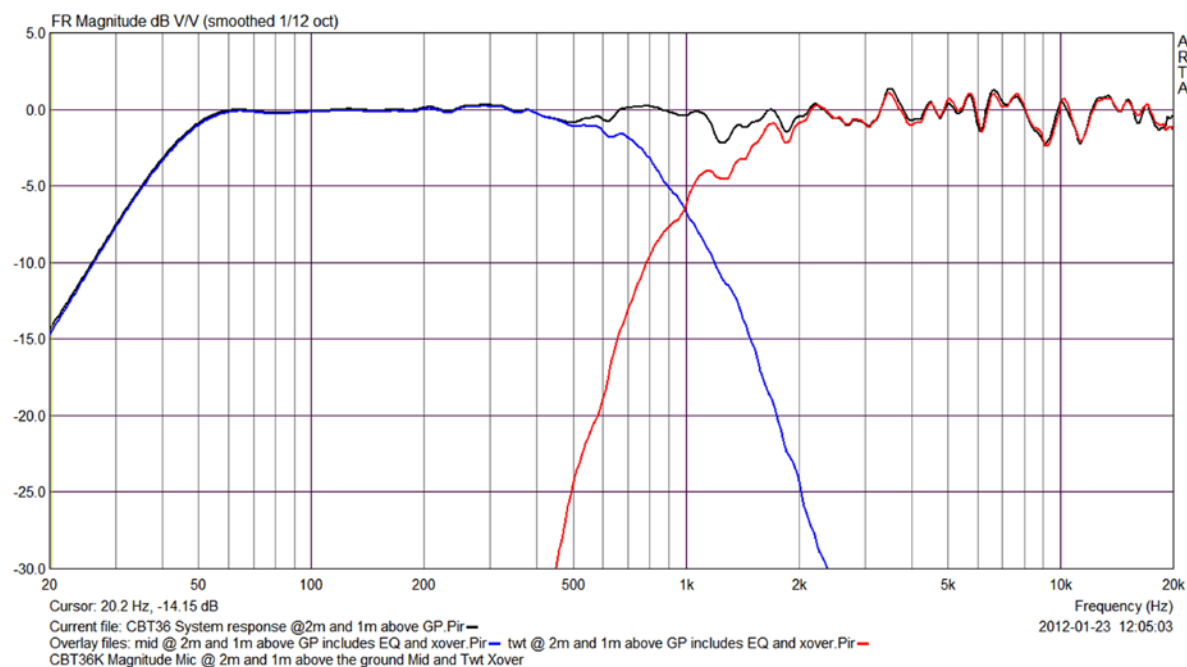


Fig. 23. CBT36 axial frequency responses (2 m out, 1 m high) with crossover is set up in flat mode (Overall: black, LF: blue, HF: red).

12.1.11.3. Crossover Transfer Functions in Rolled-Off Mode (-1 dB/octave):

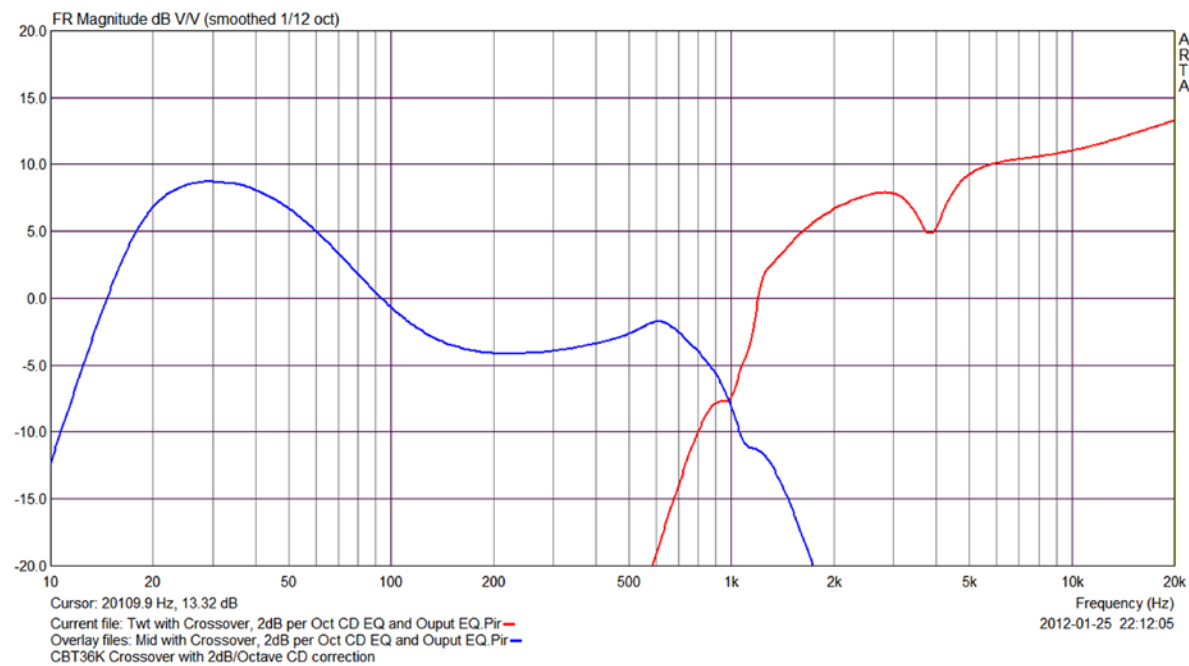


Fig. 24. Rolled-off mode DCX2496 crossover transfer functions (LF: blue, HF: red).

12.1.11.4. Resultant CBT36 System Frequency Responses in Rolled-Off Mode (-1 dB/octave):

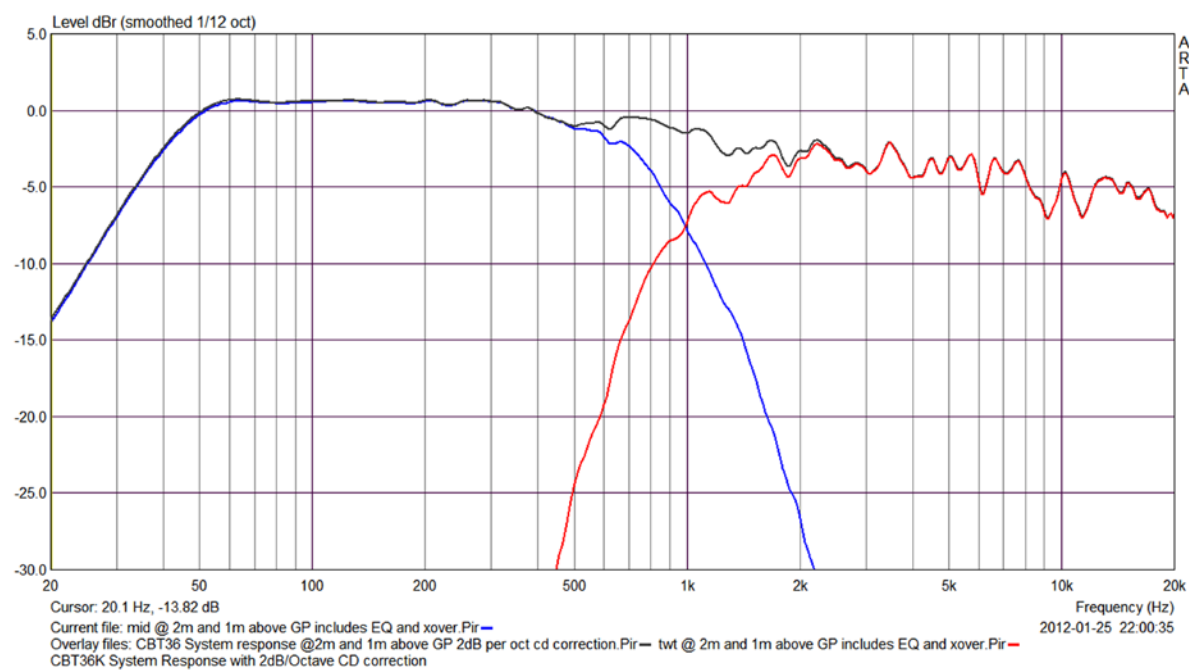


Fig. 25. CBT36 axial frequency responses (2 m out, 1 m high) with crossover is set up in rolled-off mode (Overall: black, LF: blue, HF: red).

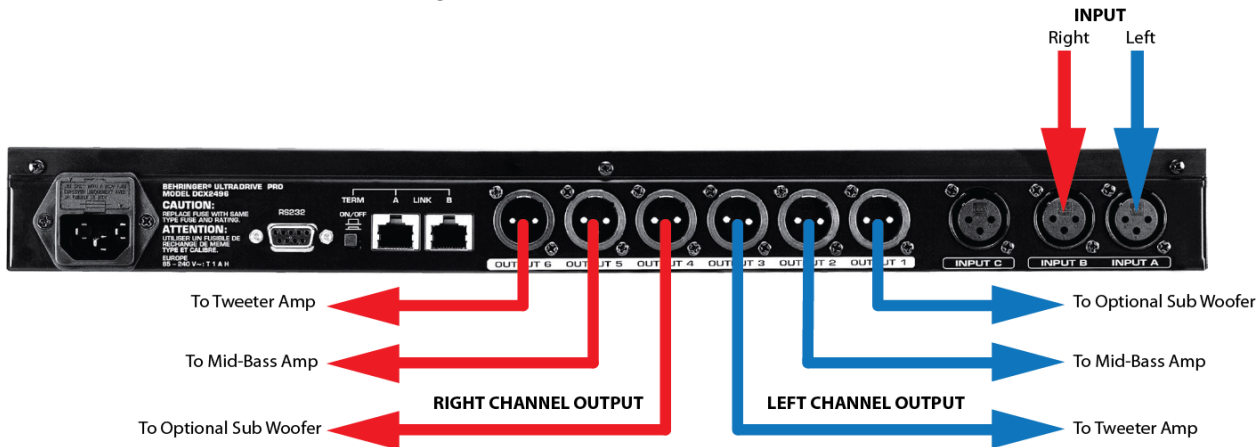
12.1.12. Measurement Agreement:

If your measured results agree, then proceed to the next section.

12.2. CONNECT THE BEHRINGER DCX2496 CROSSOVER TO THE SYSTEM:

With all equipment off and referring to the following rear panel view of the DCX2496, connect your signal source to the inputs of the crossover and then connect the crossover outputs to the power amplifiers.

12.2.1. Rear Panel View of Behringer DCX2496 with Connections:



Crossover outputs 1, 2, and 3 connect to the left system, and outputs 4, 5, and 6 connect to the right system. Outputs 2 and 5 connect respectively to the left and right mid-bass power amplifiers. Outputs 3 and 4 connect respectively to the left and right tweeter power amplifiers. Optional left and right sub woofers can connect respectively to outputs 1 and 6. Alternately, a mono sub woofer can connect to a output 1, with appropriate changes to the crossover configuration to create a left-plus-right summed output.

12.2.2. XLR to RCA Adapters:

To ease connections to single-ended amplifiers and signal sources, male and female XLR-to-RCA adapters may be used. These can be ordered from Parts Express. The following shows these adapters with Parts Express part numbers.



240-428



240-438

Once all these connections are made you are ready to test the system.

12.3. CROSSOVER FILTER/EQ SETTINGS TABLE:

The following table summarizes all the crossover filter and equalization settings that were entered into the Behringer DCX2496 Crossover:

Crossover Filter/EQ Settings Table:

Signal Block:	Num:	Filter Type:	Frequency Hz	Gain dB	Slope dB/oct	Q
CD Correction Filter, Flat Mode Setting:						
	1	Low-Shelf	401	-3.0	6	-
	2	Low-Shelf	805	-3.0	6	-
	3	High-Shelf	1600	+3.0	6	-
	4	High-Shelf	3240	+3.0	6	-
	5	High-Shelf	6430	+3.0	6	-
	6	High-Shelf	12800	+3.0	6	-
	7	High-Shelf	20000	+3.0	6	-
CD Correction Filter, Rolled-Off Mode Setting:						
	1	Low-Shelf	401	-2.0	6	-
	2	Low-Shelf	805	-2.0	6	-
	3	High-Shelf	1600	+2.0	6	-
	4	High-Shelf	3240	+2.0	6	-
	5	High-Shelf	6430	+2.0	6	-
	6	High-Shelf	12800	+2.0	6	-
	7	High-Shelf	20000	+2.0	6	-
Mid-Bass Band Pass (No Sub):						
(Best Sounding)	1	Butterworth High-Pass	20	-	24	-
(*Alternate: Provides Excursion Protection)	1*	Butterworth High-Pass	45	-	24	-
	2	Linkwitz-Riley Low-Pass	1000	-	24	-
Mid-Bass EQ:						
	1	Low-Shelf	50	+15.0	12	-
	2	Parametric	620	+1.8	-	2.8
	3	Parametric	1090	-3.0	-	5.6
	4	Parametric	1780	-1.5	-	2.8
	5	Delay	0.00 ms	-	-	-
	6	Gain	-	0.0	-	-

Crossover Filter/EQ Settings Table (Cont.):

Signal Block:	Num:	Filter Type:	Frequency Hz	Gain dB	Slope dB/oct	Q
Tweeter Band Pass:						
	1	Linkwitz-Riley High-Pass	1000	-	24	-
	2	Low-Pass	OFF	-	-	-
Tweeter EQ:						
	1	Parametric	1000	-4.5	-	6.3
	2	High-Shelf	1000	+4.0	12	-
	3	Parametric	1140	-2.4	-	10
	4	Parametric	1240	+1.5	-	10
	5	Parametric	3850	-5.0	-	5
	6	High-Shelf	7010	-3.0	12	-
	7	Delay	0.170 ms (60 mm)	-	-	-
	8	Gain	-	+1.5	-	-
Mid-Bass Band Pass (With Sub):						
	1	Linkwitz-Riley High-Pass	80	-	24	-
	2	Linkwitz-Riley Low-Pass	1000	-	24	-
Sub-Woofer Band Pass:						
	1	Linkwitz-Riley Low-Pass	80	-	24	-

13. STARTING UP YOUR SYSTEM

13.1. TURN ON THE SYSTEM:

Turn on everything except for the amplifiers. After the crossover, preamps, CD players etc. are powered on and stabilized, and with the volume set to its lowest setting, you can power up the amplifiers.

13.1.1. Listen to Low-Level Music and Make Sure Everything is Connected Properly:

Once all entries are complete, connect a signal source to the input of the crossover and the output of the crossover to the amplifiers. Then connect speaker cables to the amplifier and to the CBT36 speaker systems. Power up the amps and play music at a low level and listen with your head close to the tweeter and midrange drivers and verify that the highs go to the tweeters and the lows go to the mid-bass drivers.

The MUTE buttons on the front of the crossover can be used to good advantage here to MUTE an output channel you don't want to listen to. First mute the tweeter channel and you only be listening to the mid-bass drivers from 50 Hz to 1 kHz. They will sound muffled and dull if the crossover is working properly. Now mute the mid-bass channel and un-mute the tweeters, they should sound bright and thin because you are only listening to program material in the range of 1 kHz to 20 kHz.



IF THE MID-BASS AND TWEETERS ARE REVERSED, RETRACE THE WIRING AND CORRECT THE PROBLEM BEFORE PROCEEDING.

13.1.2. System Break-in:

Once you are certain all connections are correct bring the volume up and let the system warm up a bit. You are now ready to start listening to your system. New speakers have mechanical parts that need time to settle in. We recommend that you keep music playing through the speakers to allow them to break-in. It may take a couple of weeks for everything to stabilize.

13.2. SYSTEM CONNECTIONS: EXAMPLE OF A MODERN-DAY HIGH-END AUDIO SYSTEM:

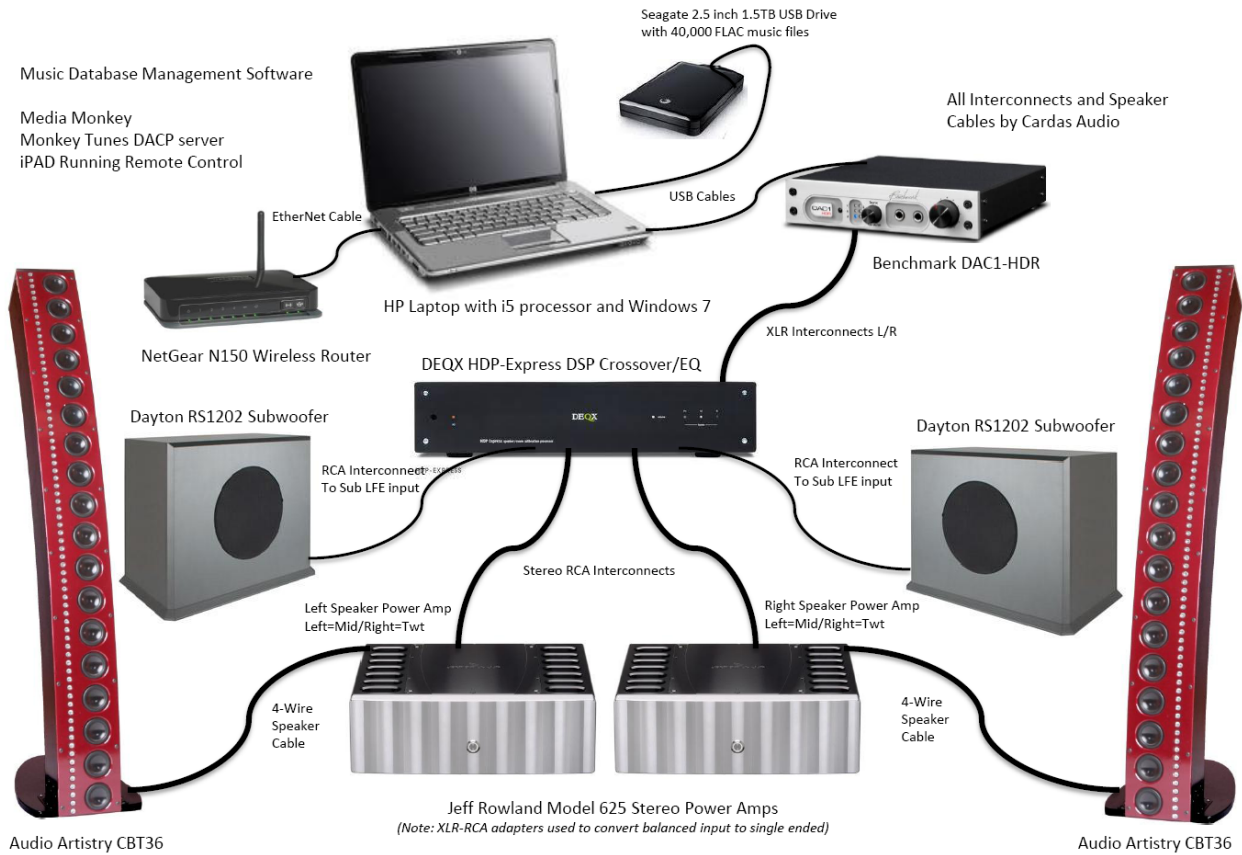


Fig. 26. System connections for hooking up a pair of CBT36 systems with signal sources, crossover/EQ, D/A converters, power amplifiers, and sub woofers. Note that the CBT36 systems are normally set up with the tweeters on the inside, *unlike the pair illustrated above.*

14. APPENDICES:

14.1. APPENDIX 1: DETAILED DESCRIPTION OF THE CBT36:

14.1.1. A Revolutionary New System Based on CBT Theory:

Marshall Kay and Don Keele brought their concept to reality in conjunction with electronics supplier Parts Express and its Dayton Audio brand of loudspeaker components to create the CBT36, the world's first broadband constant-directivity (CD) loudspeaker system for the home. The CBT36 system provides extremely even coverage and flat frequency response at all locations in the listening room. It's specifically designed to operate over an acoustically reflective ground-plane (a fancy name for the floor) and does not suffer from detrimental floor-bounce effects. Licensed under U.S. Patent numbers 7,684,574 and 7,826,622 from Harman International Industries, Incorporated.

14.1.2. CBT Theory:

CBT, which stands for $\overline{\text{C}}$ onstant $\overline{\text{B}}$ eamwidth $\overline{\text{T}}$ ransducer, is a loudspeaker line-array technology pioneered by Don Keele in six Audio Engineering Society technical papers, and is based on unclassified military underwater sound research.

14.1.3. System Description:

Each CBT36 contains 18 each 3-1/2" full-range drivers, used as mid woofers, and 72 each 3/4" diameter wide-band tweeters, that are crossed over at 1 kHz. Initially, the system will only be available in a bi-amped version but later a passive crossover may be offered. The drivers are mounted on a front panel that has a 36° circular-arc with the system standing about five feet tall and a width of about 7 inches, and a depth at the base of about 25 inches.

14.1.4. Drivers:

The 3-1/2" drivers are Dayton Audio's ND91-8, which were designed specifically for the CBT36 system. The ND91 utilizes a Neo-Balanced 1" underhung motor that is capable of over 10 mm of peak excursion and features a shorting ring to help keep distortion under control.

The very-small 3/4" diameter wide-range tweeters are also made by Dayton Audio, and feature a 0.5" edge-drive inverted aluminum dome that utilizes a high-energy neodymium magnet for low distortion and high efficiency. The tweeters are mounted on PC boards in groups of four to ease assembly and optimize center-to-center spacing. Eighteen four-tweeter assemblies (72 tweeters in all) are then mounted on the 36° circular-arc front panel which provides an extremely-even wideband narrow vertical coverage of 28°. The very-close 0.9" center-to-center tweeter spacing insures that the tweeters operate as a continuous high-frequency (HF) line source up to 15 kHz to minimize HF grating-lobe problems (http://en.wikipedia.org/wiki/Side_lobe).

14.1.5. Specifically Designed to Eliminate the Detrimental Effects of Floor Bounce:

The CBT36 has been specifically designed to operate over a reflective ground plane and does not suffer from destructive floor-bounce effects. The curved-line array of 72 tweeters extends all the way down to the floor to take advantage of the ground-plane acoustic reflection. Effectively the floor provides a reflective surface that acoustically extends the array below floor level and thus creates an array that is over 10 feet tall and controls vertical coverage and directivity down to below 160 Hz!

The system works equally well over a carpeted floor with only a moderate degradation in the HF response for points close to the carpeted floor. Listening with your ear close to the floor reveals a noticeable HF rolloff when carpet is present. With carpet, a test mic attached to a real-time spectrum analyzer confirms that the high frequencies start to be affected within about 8 inches of the floor. Apparently HF sound grazing the floor is absorbed more than lower frequencies. The real-time analyzer reveals no degradation of the sound for points higher than about 12 inches above the floor as compared to a non-carpeted floor.

14.1.6. The Restricted Vertical and Horizontal Coverage of the CBT36 Greatly Reduces

Ceiling and Wall Reflections:

The above-floor vertical coverage of the CBT36 is a narrow 28° which is extremely stable with frequency. This greatly reduces ceiling reflections as compared to a typical box style system. In addition, the horizontal coverage which is very broad narrows as you go around the side of the system, which also significantly minimizes side wall reflections.

14.1.7. Extremely Even Coverage with No Sweet-Spot Listening Axis:

The system has extremely well-behaved and smooth coverage from locations well above the array to points even down at floor level, and at distances from directly in front of the speaker to points in the rear of the listening room. The horizontal coverage is extremely broad and uniform even out to ± 90 degrees. The CBT36's variation of loudness with distance is also very unique. At standing height, the system's volume level hardly changes over a range from directly in front of the system to points 12 feet away!

14.1.8. System is Phase Linear and Time Aligned at all Frontal and Lateral Points:

One big advantage of circular-arc CBT arrays is that they are both phase linear and time aligned at all locations in front of and to the sides of the array. This behavior is not only exhibited at a magic listening "sweet spot" in front of the array but at other locations including ones above the array, to points on the floor, to points very close and far from the array, and at extreme off-axis horizontal locations around the sides of the array. On multi-way systems, such as the CBT36, this depends of course on the crossover that is used with the system. It must be adjusted to provide linear phase and time alignment at least at one point in front of the array. All other locations will then fall in line.

14.1.9. Maximum SPL and Distortion:

The system can be played extremely loud and remains very clean and effortless at all levels. The large number of drivers minimizes distortion, and driven with powerful amplifiers the system can generate very-high instantaneous peaks. See later section in this appendix titled: "CBT36 Sensitivity and Maximum SPL" for detailed information.

14.1.10. System Requirements:

The system must be bi-amped and requires an active DSP-based loudspeaker crossover/EQ along with two stereo power amplifiers. For extended bass response below 45 Hz, one or two powerful subwoofers are required. **NOTE:** *The CBT36 can't be used without an active crossover/EQ.* The CBT36 can't easily be crossed over passively because of the inherent non-flat frequency-response characteristic of curved-arc CBT arrays (see section titled "CBT36 Power Rolloff" in Appendix 2 for more information). A passive crossover is not available for the CBT36.

For this initial CBT36 product launch, we recommend two DSP loudspeaker crossover/EQ units for the CBT36, one relatively inexpensive (the Behringer DCX2496) and the other a more-expensive high-end unit (the DEQX HDP-Express). We have extensive experience with both units; the Behringer unit was used in all our CBT36 product development and the DEQX unit was used when we demonstrated the CBT36s at several audio shows.

Here are more details on both these DSP speaker processor units:

The Behringer: DCX2496 ULTRADRIVE PRO Digital Crossover:

(<http://www.behringer.com/EN/Products/DCX2496.aspx>) available from Parts Express:

(http://www.parts-express.com/pe/showdetl.cfm?Partnumber=248669&utm_source=googleps).

This manual includes detailed setup instructions for this unit.



and the DEQX HDP-Express speaker/room calibration processor:

(<http://www.benchmarkmedia.com/dac/dac1-hdr>) available factory direct from DEQX:

(<http://www.deqx.com/purchase.php>).



Two big advantages of using the more-expensive DEQX processor is that it will do automatic correction of phase/time loudspeaker errors, and will also do automatic room acoustic corrections. The DCX2496 will also correct phase/time loudspeaker errors with its delay capabilities, but it requires manual setup.

14.1.11. CBT 36 Line Drawings:

The following line drawings show two views of the CBT36. The left illustration shows a side-view cross-section taken through the center of the cabinet with bracing and mid-woofer locations indicated. The right illustration shows a front-panel view of the CBT36 with the 18 mid-woofers and 72 tweeter mounting holes shown.

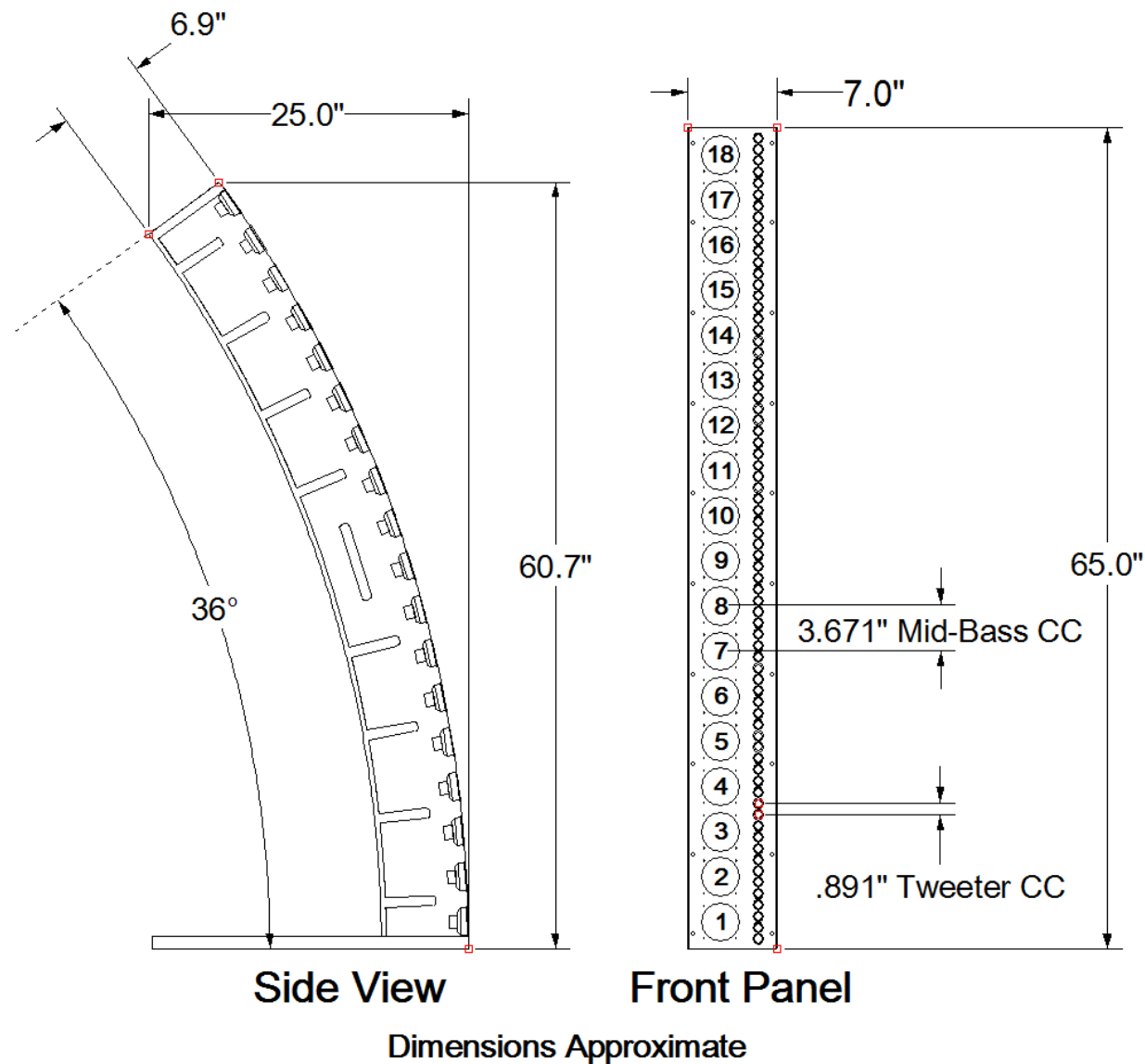


Fig. 27. CBT36 cross-sectional side view with bracing (left) and front panel (right) with approximate dimensions. The very-close 0.89" (22.6 mm) tweeter spacing insures smooth high-frequency lobe-free operation up to 15 kHz.

14.1.12. CBT36 Specifications in Brief:

14.1.12.1. Description:

The CBT36 is a ground-plane CBT two-way floor-standing 36° circular-arc high-end loudspeaker line array. Each system contains 18 each 3-1/2" full-range drivers used as mid-woofers and 72 each 3/4" diameter wide-band tweeters with a 0.5" inverted aluminum dome.

The system is broad-band constant directivity and beamwidth from 200 Hz and up and supplies an extremely-even coverage and frequency response to all parts of the listening room. The system has exceptionally well-behaved and smooth coverage from locations well above the array to points even down at floor level, and at distances from directly in front of the speaker to points in the rear of the listening room. The horizontal coverage is extremely broad, but well controlled and uniform even out to plus-minus 90 degrees.

The CBT36's variation of loudness with distance is also very unique. At standing height, the system's volume level hardly changes over a range from directly in front of the system to points 12 feet away!

In addition to providing very-even and flat coverage at all the locations listed above, the CBT36 is also linear phase and time-aligned at all the same positions! (Hey, I can hear all you doubters out there already. How can it be time aligned with all those signals coming from all those drivers? Just take it from me (Keele), it is and this can be traced back to the original CBT work done by the US Navy. I will soon be authoring an AES paper on the time and phase behavior of CBT arrays which will reinforce the points.)

14.1.12.2. Frequency Response:

60 Hz to 20 kHz, ± 2.5 dB, measured at any point over a non-carpeted floor in front of the system. With carpet, the response is equally flat but measured at points above about one foot above the floor. At lower points below one foot the high-frequency response is somewhat rolled off.

14.1.12.3. Phase and Time Response:

Linear phase and time aligned at most locations in front of and to the sides of the array.

14.1.12.4. Sensitivity (2.83 Vrms/1m):

Note: the raw sensitivity (no crossover or EQ) of the CBT36 is frequency dependent. It is roughly flat from 80 to 300 Hz and then rolls off at 3 dB/octave (10 dB/decade) up to 20 kHz. See later section "CBT36 Power Rolloff" in Appendix 2 for further explanation of this rolloff. For more details see Fig. 26 in this section. Here are some approximate sensitivity numbers at different frequencies:

80 to 300 Hz:	94 dB
800 Hz:	89 dB
8 kHz:	79 dB

14.1.12.5. Crossover:

Bi-amped at 1 kHz with 4th-order Linkwitz–Riley filters, 24 dB/octave slopes. This very-low crossover frequency insures that the horizontal coverage is well behaved and lobe free out to $\pm 90^\circ$.

14.1.12.6. Shading Bank attenuation (ranging from the bottom to the top of the array):

Bank 1: 0 dB (6 mid-bass, 24 tweeters), Bank 2: -2.5 dB (4 mid-bass, 16 tweeters), Bank 3: -4.5 dB (4 mid-bass, 16 tweeters), Bank 4: -8.0 dB (2 mid-bass, 8 tweeters), Bank 5: -11.0 dB (2 mid-bass, 8 tweeters).

The loudspeakers of the CBT36 are not equally driven but are passively "shaded" in five banks that attenuate the upper drivers with respect to the lower drivers. The drivers at the bottom of the system are on full, while the higher drivers are attenuated progressively as they get closer to the top of the array. The curved circular-arc shape of the CBT36 front panel and the shading vastly improves the vertical coverage and coverage consistency with frequency as compared to a straight-line equally-driven array.

14.1.12.7. Coverage:

Horizontal: a controlled $\pm 90^\circ$, Vertical: a very-well controlled 27° above-ground beamwidth from 250 Hz on up. The restricted vertical beamwidth greatly reduces energy directed up to the ceiling.

14.1.12.8. Nominal Impedance:

4 Ohms (Not falling below 3.9 Ohms for LF and 3.6 Ohms for HF, see following section for graphs).

14.1.12.9. Amplifier Requirements:

LF: 50 to 500 Watts. HF: 50 to 150 Watts. Higher powered amps can be used to reproduce short-term transients without clipping for high crest-factor program material.

14.1.12.10. Maximum Input Voltage and Power:

The long-term continuous power rating of the CBT36 is limited primarily by the power rating of the shading network resistors. These resistors were chosen for typical domestic listening situations with power amplifiers of no more than 200 Watts (into four Ohms) playing program material with crest factors (peak to average power ratio) no lower than 10 dB. This means that if you turn the system up to the point where typical program material just starts to clip, using a typical 200 W four-ohm rated power amplifier, and then listen at this loudness (loud!) for long periods, the system's shading resistors will not overheat. For "pro-sound" applications of the CBT36 with the CBT36s being driven hard by larger amplifiers, we recommend increasing the power of each shading resistor from 12 Watts to about 50 Watts.

Short Term (One minute or less): LF: 45 Vrms (500 Watts in 4 Ohms). HF: 21 Vrms (110 Watts in 4 ohms).

Long Term (Continuous): LF: 20 Vrms (100 Watts in 4 Ohms). HF: 15 Vrms (150 Watts in 4 ohms).

14.1.12.11. Maximum Continuous Sound Pressure Level (SPL) at 1 m:

The maximum SPL of the CBT36 is frequency dependent. It's highest from 100 to 300 Hz and then rolls off at 3 dB/octave for higher frequencies. For more details see Fig. 32 later in this section. Here are some approximate numbers (short term peak SPL is 10 dB higher). These numbers were estimated by measuring the system at 4 m (about 13 ft.) in front of the system and then referencing back to 1 m.

80 to 300 Hz: 124 dB (For one minute or less)
800 Hz: 120 dB (For one minute or less)
8 kHz: 104 dB (For one minute or less)

14.1.12.12. Dimensions:

61.0" H x 7.0" W x 25.0" D (154.9 x 178 x 63.5 cm), the base is 13.5" (342.9 cm) wide.

14.1.12.13. Weight (for single system, cabinet only):

55 lbs (25 kg). Shipping weight: 70 lbs (32 kg). Right and left systems are shipped in separate containers. All drivers and remaining parts are shipped in separate containers.

14.1.13. CBT36 Impedance Magnitude and Phase vs. Frequency:

The complex impedance magnitude and phase of the LF and HF inputs of the CBT36 are shown in the following two sections. The complex impedance of the CBT36 is extremely-well behaved. Because of the resistive attenuators in the shading networks of the CBT36, the impedance is very-well damped and exhibits extremely-low impedance variations. Your amplifiers and cables are going to love these impedances; particularly your tube amps!

14.1.13.1. Impedance Magnitude:

The impedance magnitude vs. frequency of the LF and HF sections are shown in the following two graphs (both plotted on log scales):

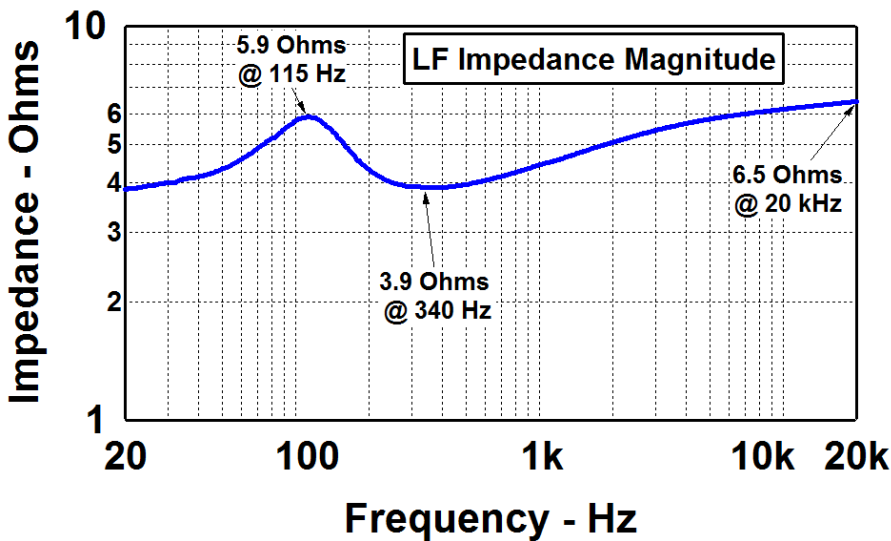


Fig. 28. Impedance magnitude of the LF section of the CBT36. The impedance exhibits a max-min variation of only 3.9 to 5.9 Ohms below the 1 kHz crossover.

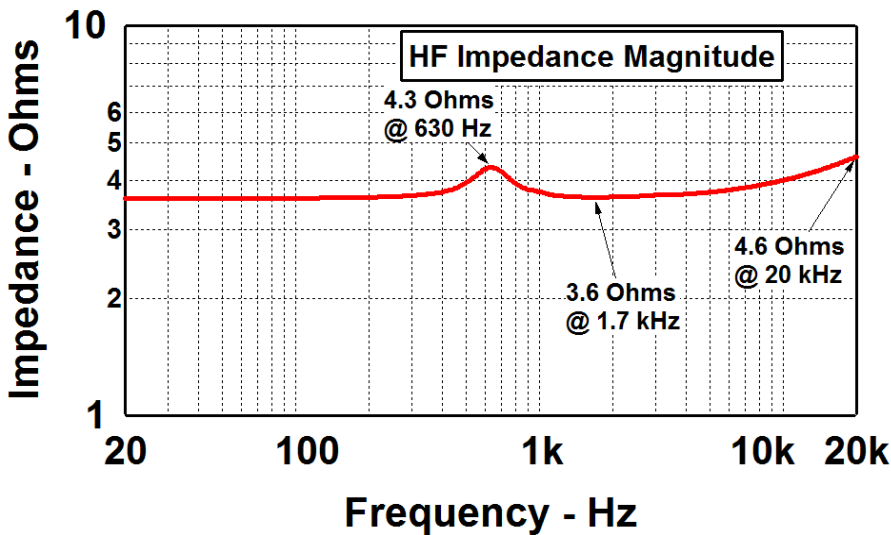


Fig. 29. Impedance magnitude of the HF section of the CBT36. The impedance exhibits a max-min variation of only 3.6 to 4.6 Ohms above the 1 kHz crossover.

14.1.13.2. Impedance Phase:

The impedance phase vs. frequency of the LF and HF sections are shown in the following two graphs. The phase of both sections exhibits very-low variation and is extremely-well behaved!

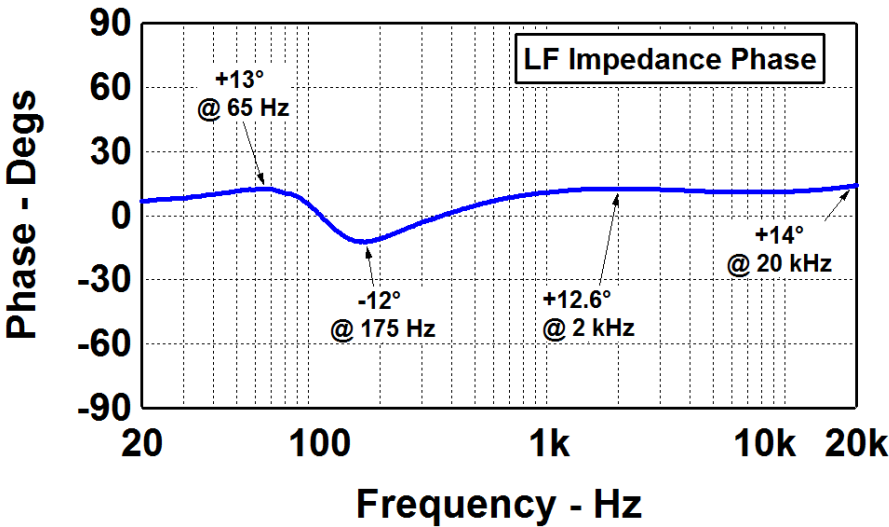


Fig. 30. Impedance phase of the LF section of the CBT36. The LF phase is also very-well behaved and exhibits variations of only about $\pm 13^\circ$ over the whole audio range!

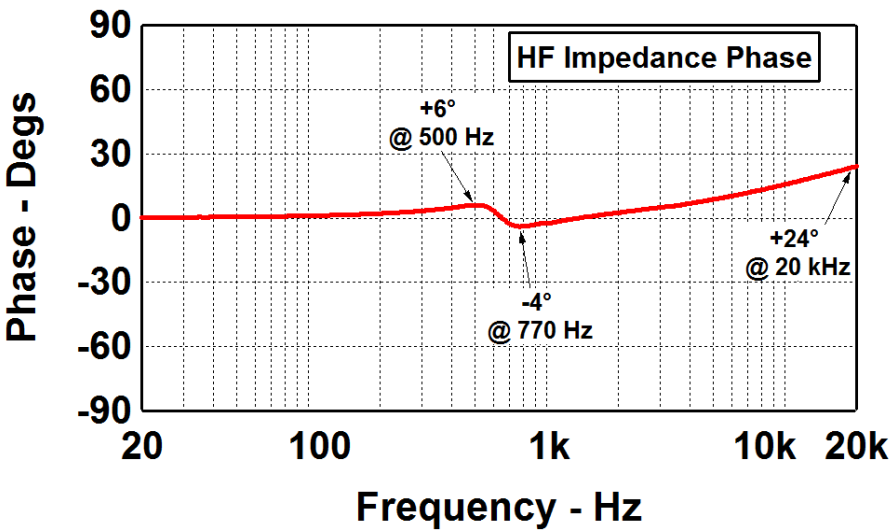


Fig. 31. Impedance phase of the HF section of the CBT36. The HF phase exhibits only a variation of -4° to $+24^\circ$ over the whole 20 Hz to 20 kHz range.

14.1.14. CBT36 Sensitivity and Maximum SPL:

The following graph shows the simulated sensitivity and maximum SPL of the CBT36. Separate curves are shown above and below the 1 kHz crossover due to different power-handling capabilities of the LF and HF sections. These curves assume no power limiting by the shading resistors internal to the CBT36 with the system set up in a “pro sound” configuration. See previous comments in section “CBT36 Specifications in Brief:” under specification “Maximum Input Voltage and Power.”

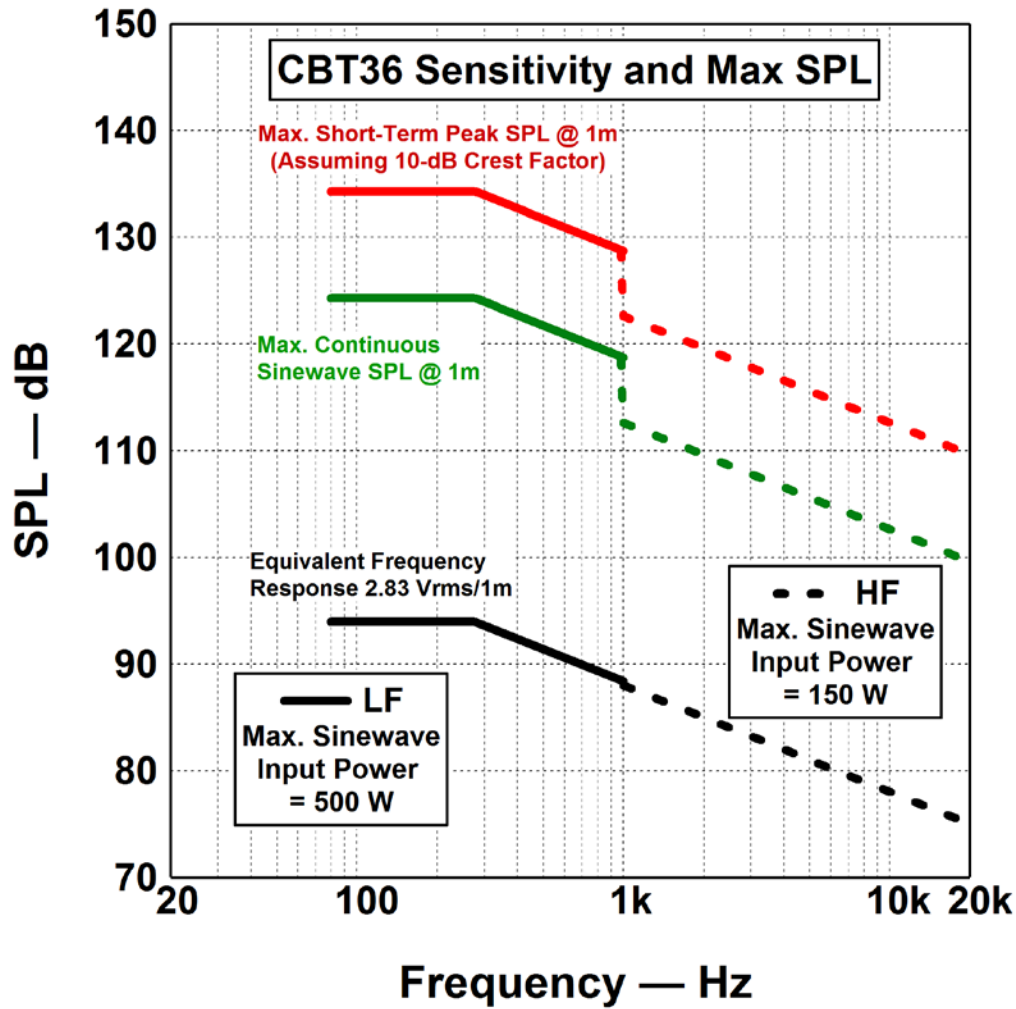
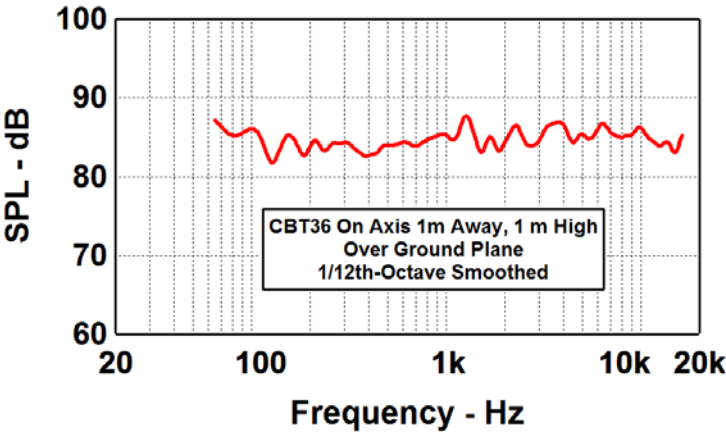


Fig. 32. Graph of the approximate CBT36 2.83 Vrms/1m sensitivity and maximum continuous and short-term SPL. The levels are frequency dependent and reach a maximum between 80 and 300 Hz. The curves roll off at higher frequencies at 3 dB/octave or 10 dB/decade. Separate curves are shown above and below the 1 kHz crossover for LF (continuous line) and HF (dashed line). For max SPL, these curves assume a “pro-sound” configuration of the CBT36 with high-power shading resistors.

14.1.15. CBT36 Ground-Plane Frequency Responses:

The CBT36 is designed to have an extremely even and well-behaved frequency response no matter where the response is measured. This includes locations very close and far away from the system, from points near the floor up to points above the system and locations at extreme horizontal off-axis points out to $\pm 90^\circ$. In addition, the system is specifically designed to operate over the floor without incurring the harmful effects of floor bounce. An additional design advantage of the CBT36 is that it effectively compensates for near-far volume level changes from locations very near the array to points 10 to 12 ft away. These attributes are briefly illustrated in the following. All the following curves were measured over the ground plane (floor). See “B&W 801 vs. CBT36 Ground-Plane Measurements” at: http://www.audioartistry.com/products_CBT.htm for a complete set of measurements and descriptions.

14.1.15.1. Traditional 1 m Response Curve (at 1 m from bottom of system, 1 m high):

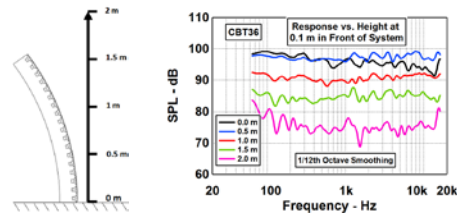


This frequency response was measured over a reflective ground-plane at 1 m out from the bottom of the system and at 1 m high. The bi-amp drive levels were set for an average level of 85 dB SPL and smoothed with a 1/12th -octave filter. Although this response curve may not be as pristine as the response curves published by other manufacturers, it is honest and represents the average response you get at most other locations in a real over-the-floor environment. Again refer to the “B&W 80 vs. CBT36” presentation mentioned above for more detail.

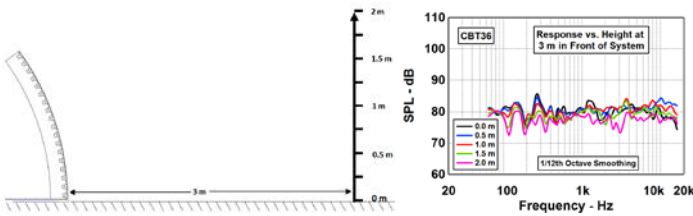
14.1.15.2. Response vs. Height in Front of System (at heights of 0, 0.5, 1, 1.5, and 2 m High):

Note how little the response shape changes with different heights! Close to the system, the level varies significantly and is loudest on the floor. Farther away, the response shape and level is quite uniform.

Directly in Front of the System at 0.1 m (4"):

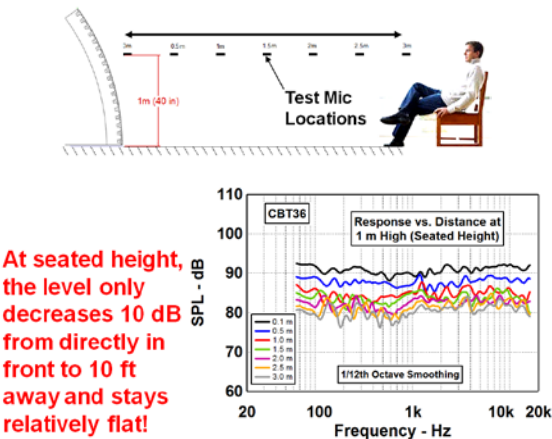


At a Distance of 3 m (10 ft.) away:

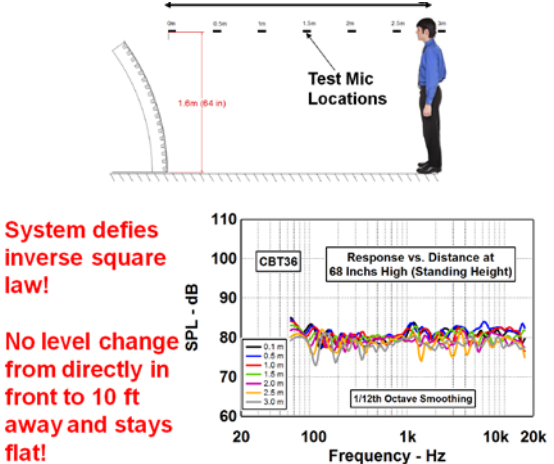


14.1.15.3. Response vs. Distance (at distances of 0, 0.5, 1, 1.5, 2, 2.5, and 3 m (10 ft) Away):

Seated Height (1 m or 40" high):



Standing Height (1.7 m or 68" high):



14.2. APPENDIX 2: CBT THEORY OF OPERATION:

14.2.1. Background:

The CBT36 is based on unclassified “CBT” military under-water sonar research done by the U.S. Navy. CBT, which stands for “**C**onstant **B**eamwidth **T**ransducer,” is a term coined by military researchers in a series of three papers published between 1978 and 1983 [1-3] (see Bibliography at the end of this section for reference numbers in brackets). This research resulted in under-water transducers that exhibited extremely even coverage independent of frequency and distance. The CBT36 is the result of applying this research to high-end home loudspeaker systems.

14.2.2. Application to Loudspeakers:

Don Keele applied this theory to loudspeaker arrays in a series of six pioneering Audio Engineering Society papers written between 2000 and 2010 [4-9]. Don is a designer and engineer that's been involved with “Constant Directivity” professional loudspeakers and horns since the early 70s. These systems are designed to have extremely-even coverage and flat frequency response over wide angles both horizontally and vertically. His goal was to design a line array loudspeaker system for domestic and home theater environments that exhibited the same characteristics.

14.2.3. Design Goals:

The design goal of the CBT36 was to create a no-holds-barred high-end line array loudspeaker for home use with extremely even coverage at all points in the listening room and with broad-band constant-directivity (CD) behavior. This type of speaker would have no preferred so-called “sweet spot” listening axis and associated listening distance for optimum sound. It would sound good no matter where you listened to it; whether sitting down, standing up, laying on the floor, listening directly in front of the system from six inches away or 12 feet away, or listening to the system way off to one side.

An additional goal of the system was to completely eliminate the deleterious effects of floor bounce and create a system that would work located on a hard reflecting surface such as a tiled non-carpeted floor without exhibiting frequency response comb filtering or other aberrations.

14.2.4. CBT36 Design:

The design of the CBT36 may be summarized in three design targets:

14.2.4.1. *Extremely Even and Uniform Frequency Response:*

The CBT36 has very even frequency response from listening points ranging from up and down, side to side, and from near to far.

Up - Down:

The frequency response is quite uniform from listening locations on the floor to points significantly higher than the array itself, and all points in between!

Side to Side:

The CBT36 has extremely even and wide, but well-controlled, horizontal coverage that extends over very-wide angles from $\pm 90^\circ$ from directly in front of the system.

Near and Far:

The CBT36 has extremely even and flat frequency response from points even as close as 3" (75 mm) from the front panel of the system to points 10 to 14 ft (3 to 4 m) away. The CBT36 can be used as a perfect near-field monitor because the systems can be placed as close as 2 ft (0.6 m) from each other and listened to from locations only 2 to 3 ft (0.6 to 1 m) away!

14.2.4.2. *Eliminates the Deleterious Effects of Floor Bounce:*

Most speakers exhibit comb filtering effects due to the sound of the speaker bouncing off the floor. The floor-bounce effects depend highly on the distance and height of the listener. The vertical coverage of the CBT36 is essentially perfect from points on the floor to above the array and from distances from very close to far away. This is true because the system is a ground-plane design specifically intended to operate over a reflective surface [8].

14.2.4.3. *Compensates for near-far variation of sound level:*

The CBT36 compensates for level variations with distance as compared to traditional box-style speaker systems. At seated height, the level only decreases 10 dB from directly in front to 10 ft (3 m) away and stays relatively flat! For standing listeners, the sound level of the CBT36 hardly changes from listening points directly in front of the array to points 10 feet (3 m) away!

14.2.5. Brief Review of Military Underwater CBT Technology:

The original CBT military under-water sonar research [1-3] was applied to so-called “spherical-cap” (<http://mathworld.wolfram.com/SphericalCap.html>) underwater transducers with special frequency-independent “Legendre” shading. This shading provides wide-band extremely constant beamwidth and directivity behavior with virtually no side lobes. The technique works without the need for any special or complex signal processing. The shading is just a simple level adjustment of the individual elements that make up the transducer.

The following figure shows several illustrations from the original Navy under-water CBT research papers:

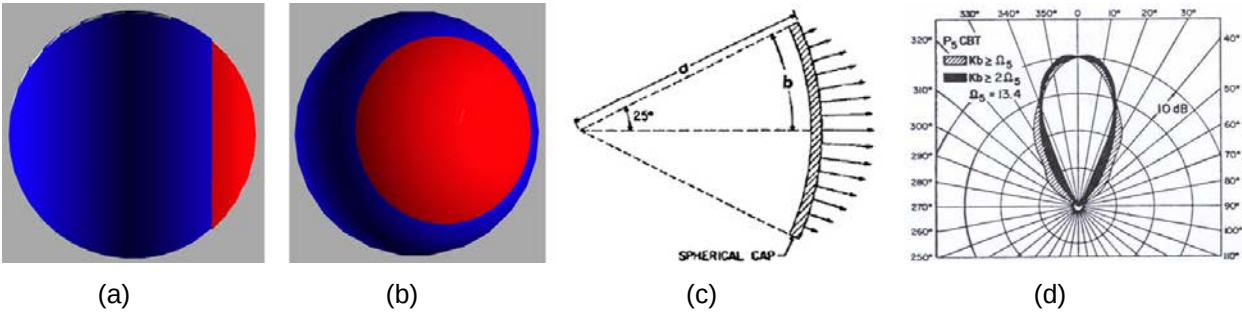


Fig. 33. Illustrations from the original U.S. Navy technical papers showing a spherical cap (in red): (a) side view, (b) oblique front view, (c) side view of a 50° spherical cap with “Legendre” shading (the length of the arrows indicate the strength of the shading which is maximum in the center of the cap and decreases towards the outside of the cap), and (d) an overlay of several measured polar curves or beam patterns for the 50° spherical cap radiator shown in (c). (d) Illustrates the extreme uniformity of the CBT radiator polar curves with frequency.

14.2.6. OVERVIEW of KEELE’S CBT LOUDSPEAKER TECHNOLOGY:

Don Keele applied the technology to loudspeaker arrays in a series of six AES papers between 2000 and 2010 [4-9]. The following illustrates the three different types of CBT loudspeaker arrays that Keele proposed and analyzed.

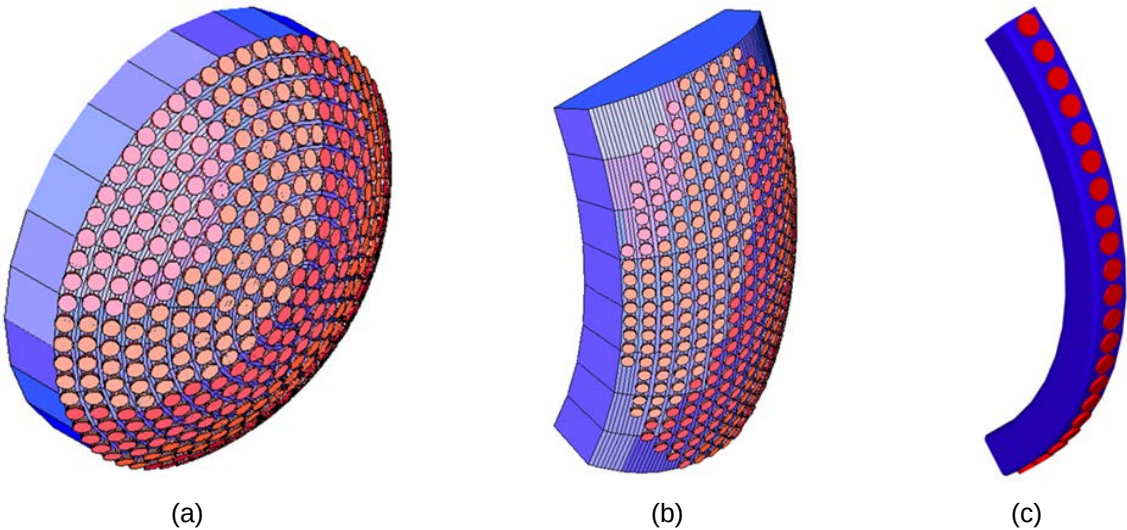


Fig. 34. Three types of CBT loudspeaker arrays analyzed by Keele (the red dots indicate loudspeaker locations): (a) circular spherical-cap array, (b) elliptical toroidal-cap array, and (c) circular-arc line array.

The first two arrays (a) and (b) control coverage in both planes, while the third array (c) controls coverage in the vertical plane only but provides wide horizontal coverage. The CBT36 is a circular-arc line array (c) and is the only type of CBT array considered further in this section.

14.2.7. Free-Standing versus Ground-Plane CBT Line Arrays:

There are two types of CBT line arrays: 1) a free-standing array and 2) a ground-plane array. The free-standing CBT array can be operated in free space and does not require mounting near any reflecting surface. The ground-plane CBT array is essentially one half of a free-standing array that is intended to operate near or very close to a single acoustic reflecting surface, such as a floor, wall, or ceiling. The reflecting surface essentially doubles the size of the array by recreating the missing half of the array. The CBT36 is a ground-plane CBT line array. The following figure illustrates a free-standing array and a ground-plane array with its acoustic reflection along with typical shading values. Shading is explained in the next section.

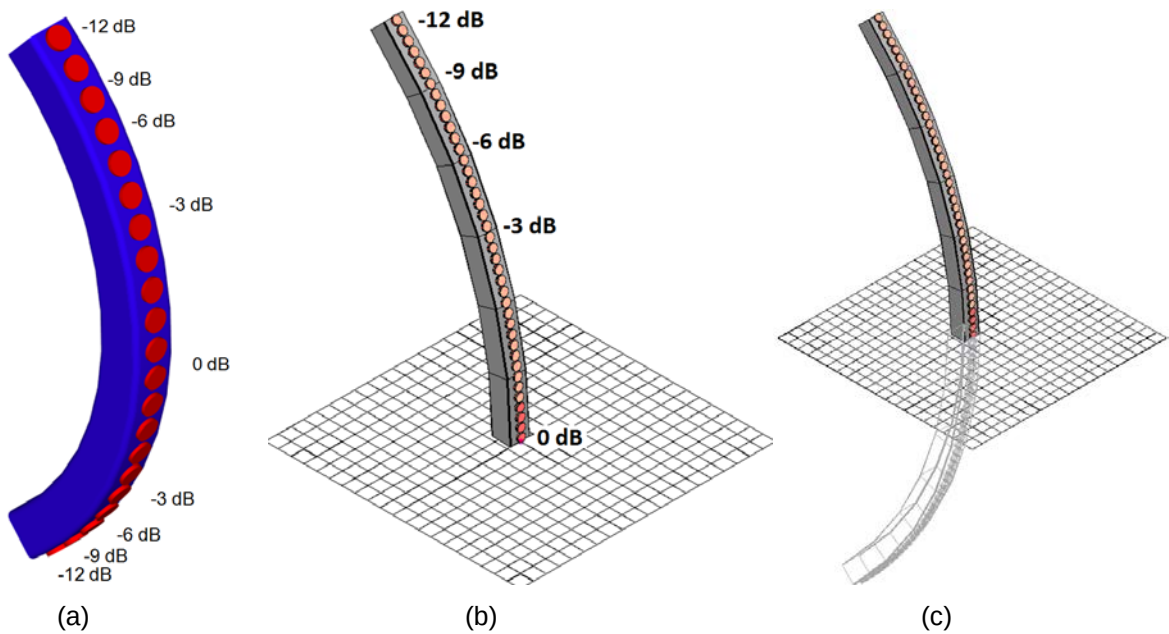


Fig. 35. (a) A free-standing CBT line array with shading. (b) A ground-plane CBT line array with shading. (c) A ground-plane CBT line array with acoustic reflection that essentially doubles the size of the array.

14.2.8. Shading:

In addition to mounting the drivers on a circular arc, a CBT loudspeaker array requires shading or level adjustment of each driver with respect to other drivers that make up the array. This maintains the best coverage independent of frequency. **NOTE:** This shading or level adjustment is a simple fixed change of volume of a particular loudspeaker and is independent of frequency. References [4] and [7] go into much detail on the CBT shading.

The level adjustment or attenuation value for each driver depends on where the driver is located in the array. For a free-standing array, the drivers in the center of the array are at a maximum while the drivers at the outside of the array are attenuated.

For the CBT36 ground-plane array, the drivers on the bottom near the floor are turned on full and the drivers at the top are attenuated the most. The drivers in between the bottom and top have intermediate attenuation values.

The required theoretical shading values are illustrated in the following graph in a continuous curve. The curve starts at 0 dB at the bottom of the array (left) and falls smoothly to -13.5 dB at the top of the array (right). The bottom of the graph shows the location of the 18 individual woofers in the CBT36 array numbered from 1 to 18 going from bottom to top. Details about this truncated Legendre shading method are shown in reference [7].

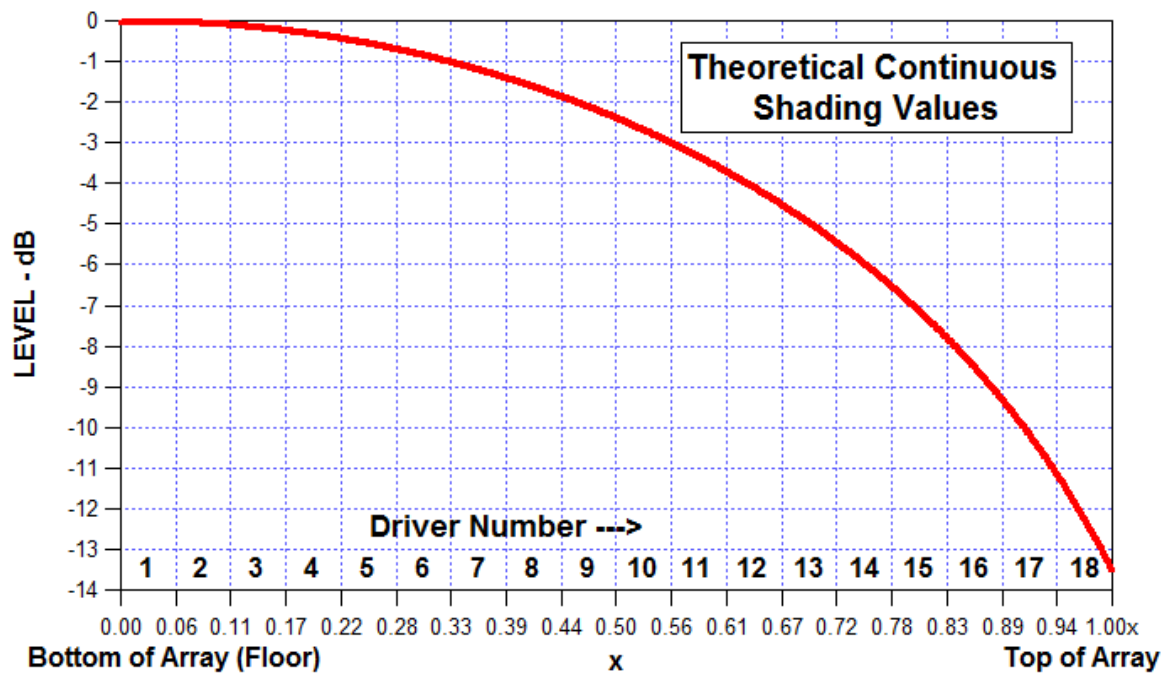


Fig. 36. Theoretical Legendre truncated (-13.5 dB) continuous shading curve for a ground-plane CBT array [4] [7-8]. The drivers at the bottom of the array (left) are turned on full while the drivers at the top of the array (right) are fully attenuated.

The most straightforward way to implement the driver shading would be to drive each speaker in the array with its own amplifier whose gain could be adjusted appropriately for each driver depending on its location in the array. However, this is complicated and expensive. Fortunately from a practical standpoint, the continuous shading can be approximated by dividing the drivers into multiple banks, each of which are attenuated in a series of steps [7]. Furthermore, the attenuation of each bank can often be implemented passively without requiring separate amplifiers for each bank.

The CBT36 uses 18 mid-woofers and 72 tweeters. **NOTE:** *There are exactly four tweeters for each mid-bass driver ($4 \times 18 = 72$).* The 18 mid-bass drivers and 18 four-tweeter PC-board modules of the CBT36 are divided into five banks which are passively attenuated using series-parallel connection combinations and resistive attenuators (the CBT36 schematics were shown earlier in the “Wiring” section of this assembly manual).

The following table (Table 1) shows the five CBT36 mid-bass and tweeter banks along with their attenuations:

Table 1: CBT36 Woofer and Tweeter Attenuation Banks:

Bank Number:	Attenuation:	Mid-Bass:	Tweeters:
1 (Bottom)	0 dB	6 Woofers, Drivers 1 - 6	24 Tweeters, Drivers 1 - 24
2	-2.5 dB	4 Woofers, Drivers 7 - 10	16 Tweeters, Drivers 25 - 40
3	-4.5 dB	4 Woofers, Drivers 11 - 14	16 Tweeters, Drivers 41 - 56
4	-8.0 dB	2 Woofers, Drivers 15 - 16	8 Tweeters, Drivers 57 - 64
5 (Top)	-11.0 dB	2 Woofers, Drivers 17 - 18	8 Tweeters, Drivers 65 - 72

This shading method essentially approximates the continuous shading curve shown in the previous figure with a series of steps [7] and is illustrated in the next figure. The graph shows the actual stepped shading for the 18 mid-bass drivers with the attenuation shown for each bank. The attenuation levels of the tweeters are exactly the same except there are four tweeters for each mid-woofer.

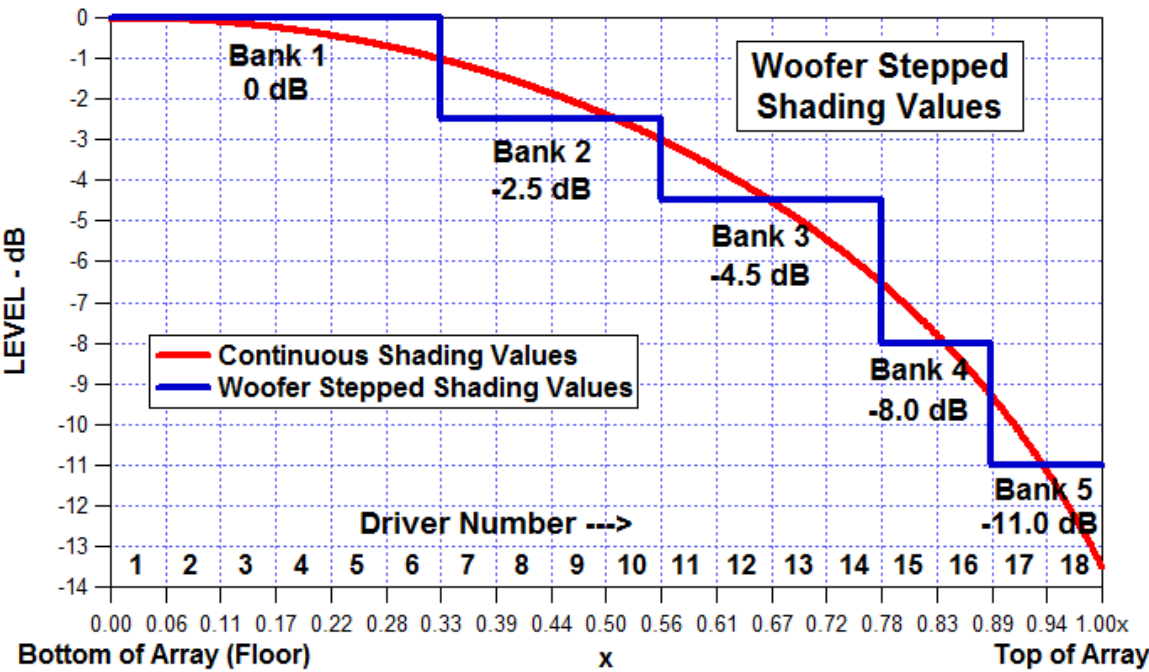


Fig. 37. CBT36 stepped-shading approximation (blue) of the continuous shading curve of the previous figure (red). The drivers at the bottom of the array (left) are turned on full while the drivers at the top of the array (right) are fully attenuated. The five bank attenuations are respectively 0, -2.5, -4.5, -8.0, and -11.0 dB going from the bottom of the array to the top.

The next subsection shows a pictorial view of the CBT36 with side and front views indicating driver shading banks and attenuations.

CBT36 Front Panel with Shading Banks and Attenuation:

The following figure shows the front panel of the CBT36 with the driver banks and attenuations indicated. The CBT36 shading schematics are shown in the “Shading-Network” sections of this assembly manual.

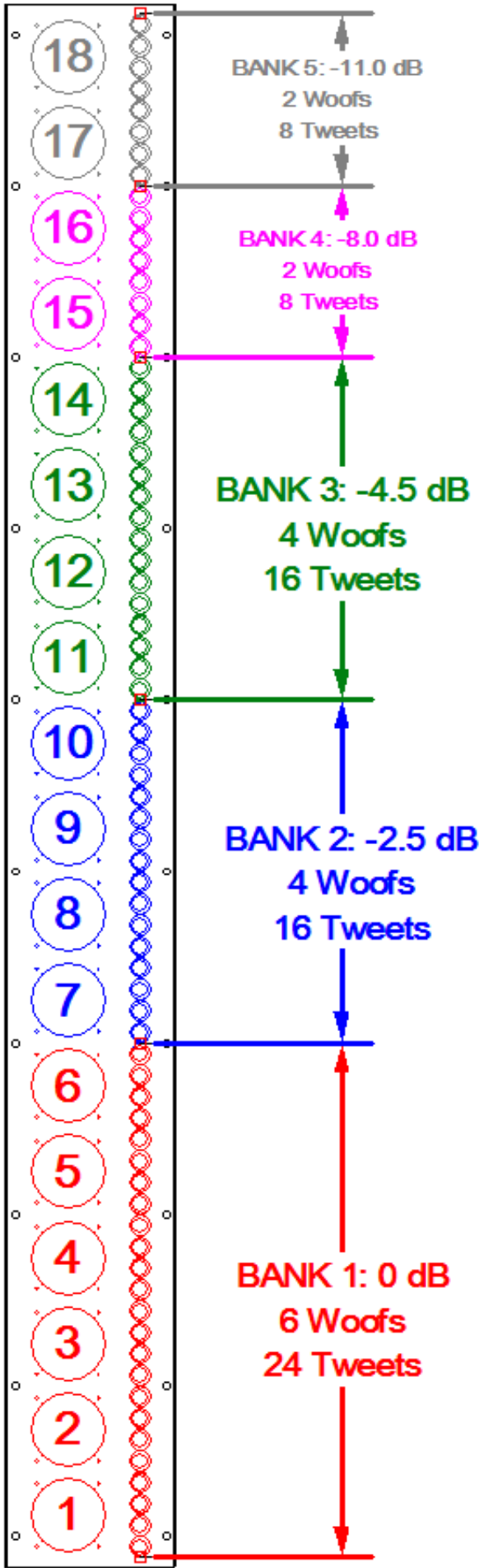


Fig. 38. Front panel of CBT36 with driver bank organization and shading attenuations indicated.

14.2.9. CBT36 Enclosure Design:

A most obvious question about the enclosure is why is it circularly curved? The reason can be traced back to the original military underwater transducer research where they analyzed a spherical-shaped round transducer. The theory was applied to loudspeaker line arrays by assuming a circularly-shaped line array. This is the shape that results if several loudspeakers are arranged in a straight line and then wrapped around a sphere. This is the configuration analyzed in Keele's first paper of 2000 [4]. The circular-arc array provides very uniform and well controlled vertical coverage with very wide horizontal coverage that is independent of frequency and distance and *does not require any complicated DSP processing*.

So why keep it curved? Three reasons:

Firstly, the circular shape dramatically simplifies the required processing to have constant coverage with frequency. The processing required for a straight-line array to provide the same coverage control as a circular-curved array is extremely complicated! Each individual speaker in the array would require its own power amplifier with complex DSP and delay capabilities built in. Furthermore, the required processing is strongly frequency dependent.

The processing required for a circularly-curved array is extremely simple and is not frequency dependent. Just a simple frequency-independent amplitude shading adjustment of each speaker is required. In most cases the processing can be done completely passive with only a single power amplifier required! This is what's done with the CBT36 with the exception that two power amplifier channels are required for each speaker for the LF and HF bi-amplification.

Secondly, the circular shape guarantees circular constant-phase wave fronts in the vertical plane from points very near the array to points very far away. This means that the vertical coverage of the array is essentially independent of distance! The coverage of a CBT circular-arc array is so uniform that it essentially has no near field. Its frequency response is the same at 3 inches away from the surface of the array as it is at 10 feet away!

Thirdly, the circular shape of the enclosure dramatically increases the strength of the enclosure and allows thinner materials to be used for the front and back panels which must be bent to conform to the cabinet shape. The thinner front panel allows the front to be easily bent around the front of the enclosure even with all the drivers attached. All though thinner, the cabinet still will be much stronger than if the cabinet were constructed with thicker materials but not be curved.

14.2.10. CBT36 Beamwidth vs. Frequency:

The following graph shows the simulated above-ground-plane beamwidth of the CBT36 with frequency. Beamwidth is the angle at which the level (SPL) drops 6 dB from a reference direction (<http://en.wikipedia.org/wiki/Beamwidth>, note however that for antennas the level drop is defined as 3 dB). Note how extremely uniform the CBT36 beamwidth is for frequencies above 200 Hz! For the vertical beamwidth, the reference direction is a line on the floor. Vertically, the graph indicates that the level drops by about 6 dB at an angle of about 27° above the floor. This narrow vertical coverage greatly minimizes energy bounced off the ceiling.

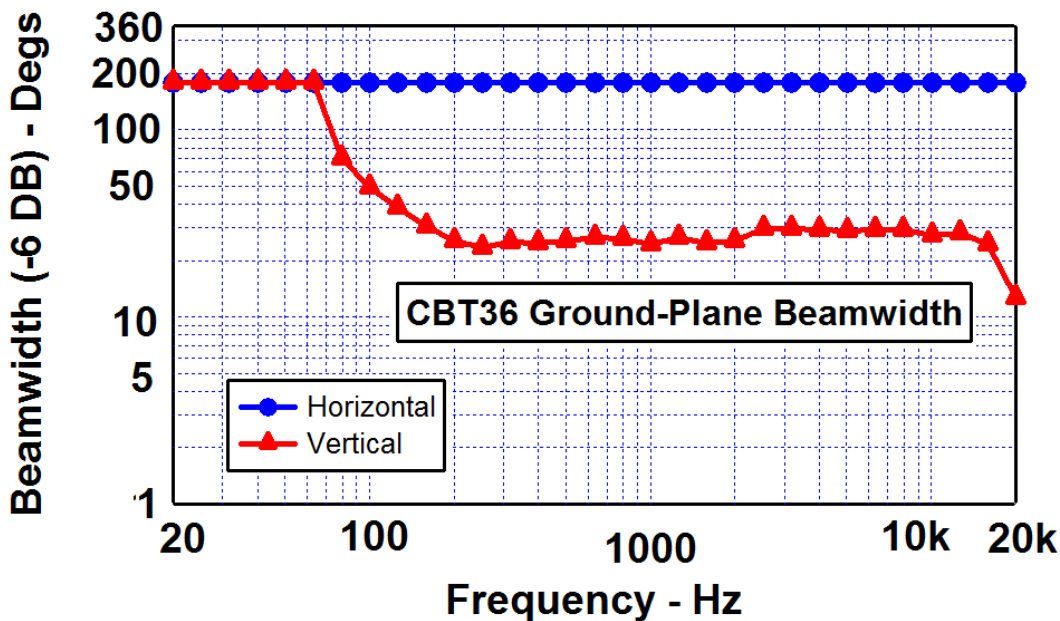


Fig. 39. Simulated beamwidth vs. frequency of the CBT36. The graph shows that the horizontal coverage of the CBT36 is essentially omnidirectional over the range of $\pm 90^\circ$. The CBT36 vertical coverage however is tightly controlled above 200 Hz at a beamwidth between 25° to 30° degs above the ground plane.

14.2.11. CBT36 Directivity vs. Frequency:

The following graph shows the simulated directivity of the CBT36 with frequency. Directivity is a measure of the energy concentration in a particular direction compared to the total sound-energy radiated. The graph shows that the directivity of the CBT36 is quite uniform above 200 Hz. ***This indicates that the CBT36 is a true broadband constant-directivity loudspeaker.***

The following web links further explain the concept of directivity and how it applies to loudspeakers:

- 1) <http://en.wikipedia.org/wiki/Loudspeaker#Directivity>,
- 2) http://www.linkwitzlab.com/Constant_directivity_louds.htm,
- 3) <http://www.mcsquared.com/directvt.htm>).

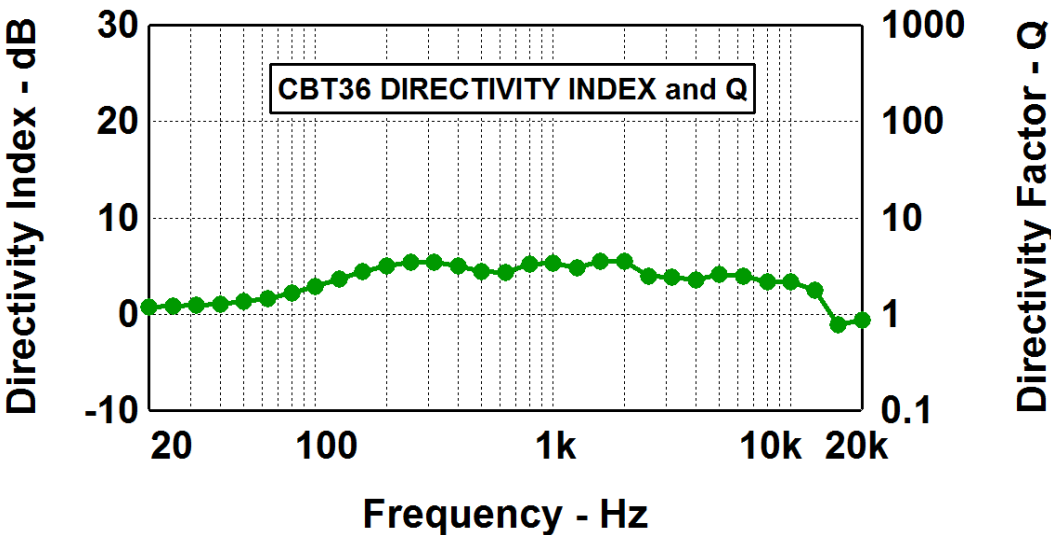


Fig. 40. Simulated directivity vs. frequency of the CBT36. Note how uniform the directivity is above 200 Hz.

14.2.12. CBT36 Power Rolloff:

One inherent characteristic of a circular-arc loudspeaker array is a power rolloff with increasing frequency as compared to a straight-line array. In the case of a curved-arc CBT loudspeaker array, the power rolloff is 10 dB/decade or 3 dB/octave throughout the frequency range where the vertical beamwidth is controlled.

For the CBT36, this rolloff commences at about 200 Hz. The power rolloff is down about 10 dB at 2 kHz and 20 dB at 10 kHz. This power rolloff must be compensated with corresponding lift equalization in the DSP active crossover. The following graph shows the simulated power rolloff of the CBT36. Note that the actual response curve of the active crossover includes the inherent responses of the system's drivers.

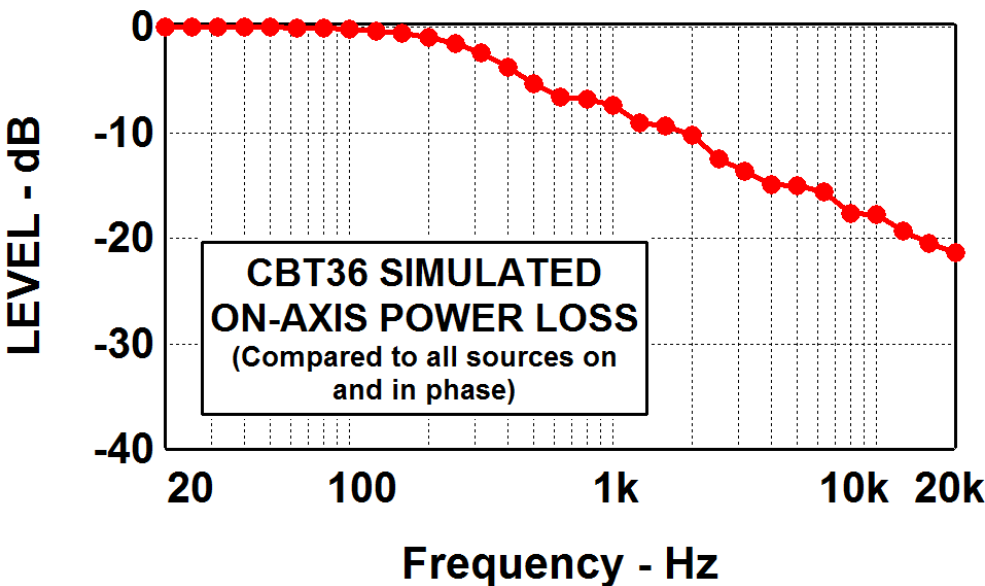


Fig. 41. Simulated CBT36 power rolloff with frequency. This is an inherent characteristic of curved loudspeaker line arrays in general and not just curved-arc CBT arrays. The rolloff starts at 200 Hz and then falls at -10 dB per decade or 3 dB per octave throughout the frequency range where the vertical beamwidth is controlled. This must be compensated by corresponding lift equalization before the power amplifier.

15. CBT36 FRONT-PANEL WIRING FOLDOUT

This is the location where the full-size wiring foldout will be inserted. The foldout will show a photo of the rear-side of both front panels laid out side-by-side with all wiring completed. Carefully compare your final completed assemblies with this detailed high-resolution photo before you attach the front panels to the enclosures.

On the rear side of the foldout will be a full-length high-resolution CBT36K wiring diagram just like the image to the right.

CBT36K Wiring Diagram

