

Construction of an Experimental Tetrahedral Ambisonic Microphone

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PLEASE READ ALL OF THESE INSTRUCTIONS BEFORE BEGINNING.

Wiring the tetrahedral frame:

Parts list:

- 4 PUI AUM-5247L-R electret microphone capsules
- 4 1-pair shielded wire, about 12" lengths (cut from 4-pair snake)
- 1 3-inch length of 3/8-inch shrinkable tubing
- 2 black tie-wraps

Tools and materials:

- Completed tetrahedral frame
- Epoxy, 5-minute (be sure it is fresh)
- Pair of pliers
- Rubber band
- Shrink tube blower or hair dryer or other heating device
- Soldering iron, pencil type
- Solder
- X-Acto knife or similar with a new blade
- Wire cutters/strippers

Process with pictures:

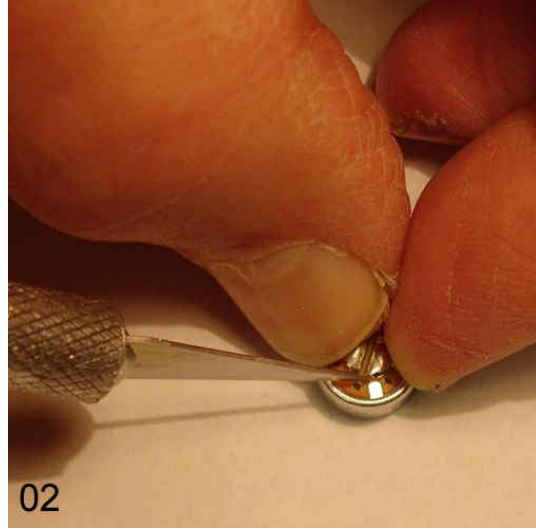
Note: Some things are better described in pictures. I tried to do that as much as possible; at times I used the timer on my camera to show things that required my two hands. There are times that the length of the timer was too short to get things in front of the lens, and I will describe those in text! The numbers of each step match up with the picture numbers. Picture numbers are 2-characters wide since most computer programs, even photo software, look at alpha-numeric increments rather than numeric ones.

CAUTION! You will be dealing with HOT wires and MOLTEN solder. All of it can burn you if you do not let it cool before touching. This includes the tools that are often used both to hold parts in place and as heatsinks to keep from destroying the component.

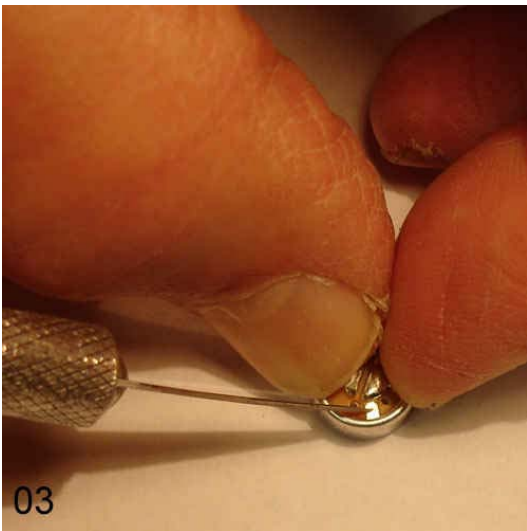




01



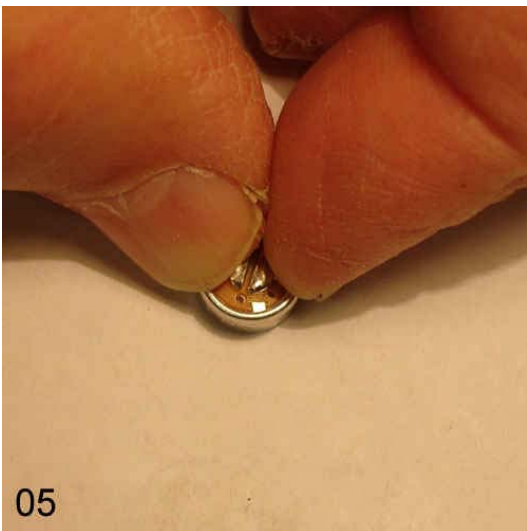
02



03



04



05

01-05. The electret microphone capsules are manufactured as 2-terminal devices. There is an FET (field-effect transistor) inside the capsule, one terminal of which is connected to the case of the capsule externally. The first step is to cut that connection and make the capsule a 3-terminal device. This greatly increases the dynamic range and the clipping level of the microphone.

CAUTION! Place a piece of paper on your work surface to help protect the faces of the 4 capsules. Figure 01 is a before and after. Notice in Figures 02-05, neither my finger nor my thumb are in line with the path of the knife cut. Be careful and keep all of your digits intact. Also, be careful not scrub the face of the capsule on the paper surface.

On the back side of the capsule, there are 2 terminals. One of them (terminal 2) is connected to the capsule case by 3 small printed circuit traces. Close to terminal 2, the trace becomes narrower, unless the solder on the terminal is covering the narrow part. Using an X-Acto knife with a new blade (very sharp), cut a

small portion of each trace that connects the case to terminal 2 on the back side of each capsule. Make 2 cuts per trace: one (Figure 02) next to the terminal and one close to the first (Figure 03), but with a definite yet minimal space. You may need to make several cuts per “cut” to go through the trace. Carefully remove the cut segment (Figure 05) and avoid getting any debris in the holes in the capsule back. Scrape the middle trace (Figure 1 – right) a bit to remove any plating residue, if any is present, but do not go too deep into the trace. This trace is now terminal 3 of the capsule.

Set the capsules aside.



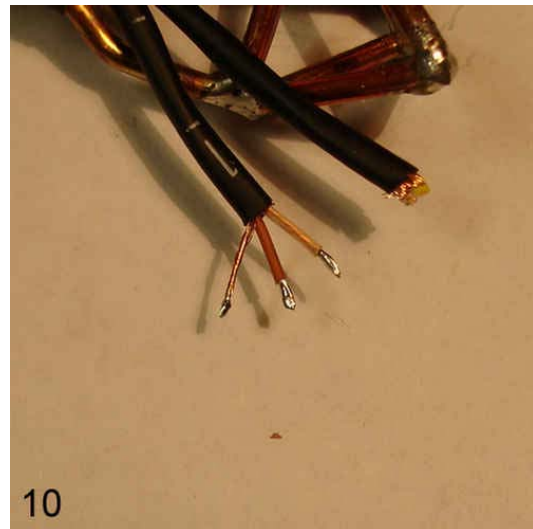
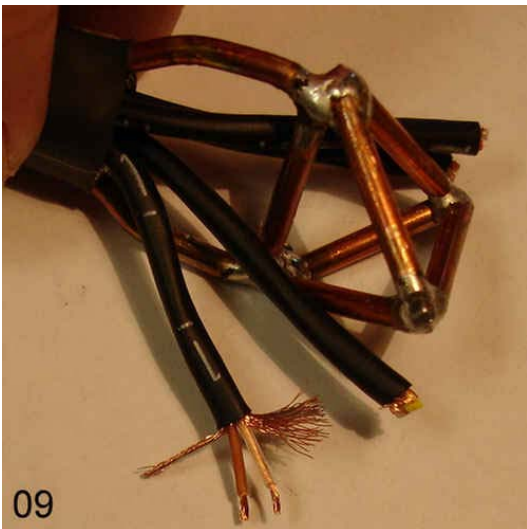
06-07. Slide a 2 $\frac{3}{4}$ -inch piece of shrinkable tubing over the all-thread of the tetrahedral frame. It should leave about $\frac{1}{4}$ -inch of thread at the bottom and cover the soldered junction of the pipe to the U-frame.

[Advanced hint: If your shrink tube has a white line on it, the line should be positioned 45 degrees clockwise from one of the U-frame legs, looking from the top of the tetrahedral. See Figure 07. When routing the pairs through the tetrahedral (See Figures 11-14.), be aware of the position of pair 1 relative to the white line. Pairs 1 and 2 will eventually be tie-wrapped to the U-frame leg closest to the white line. See Figure 18. The white line will eventually be the approximate front of the microphone.]

With a hot-air gun, shrink the tubing in place, starting at the tetrahedral end. Be sure the junction remains covered with the shrinkable tubing. Let the structure cool.



08. Align the 4 lengths of shielded wire so that the wire numbers are 2-1-3-4 clockwise. You should be able to push the wires through the tube from the bottom. The slight twist as shown in the picture is not usually necessary. Push the ends past the top of the tetrahedral and undo any twist you may have through the pipe by pulling all of the wires together back and forth while untwisting.



09-10. Strip off about 3/8-inch of the outer jacket of pair 1. You will notice that the shielding consists of both copper and tinned wires. With the colored wire (as opposed to the wire with clear insulation) in the center, gather 10-12 strands of the copper shield wired from the side opposite the clear wire and lightly twist them. Do not include any of the tinned wires in this bundle because they are stiffer than the copper strands. Gather the remaining copper and the tinned wires and cut them off even with the black outer jacket. Strip only about 1/16-inch of the insulation from the 2 inner wires. Tin the ends of the insulated wires and tin just the very end of the copper shield; it will be soldered to the new terminal 3 of the capsule. Too much solder reduces the flexibility we will need shortly. Trim the pointy end off of the shield wire to remove the point.

Notice that pair 1 has brown and clear wires. Each of the remaining pairs has a different color in combination with clear.

Do not overheat the tabs or the terminals when soldering wires to the capsule. Damage to the capsule can result, including the capsule response.

11. Route the pair through the tetrahedral as shown. Tie a rubber band around the handles of a pair of regular pliers so it will just hold a capsule securely. The pliers should be easy to open and close with just a little pressure. Place the capsule in the jaws as shown.



(Note: The copper shield wires should not be twisted too tightly; a lighter twist will add flexibility.)

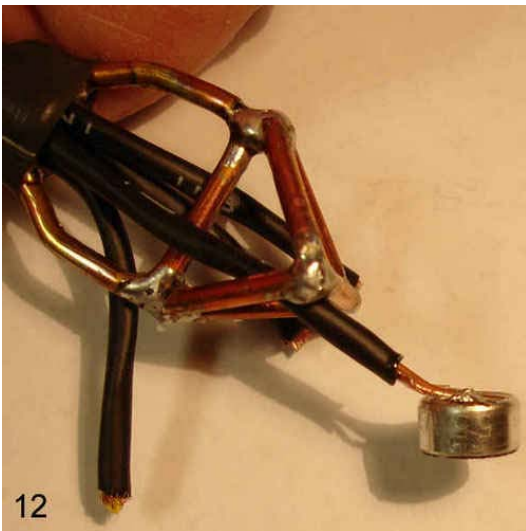
Solder the clear wire to the number 1 terminal (away from the cut tabs) and then the colored wire to the number 2 terminal.

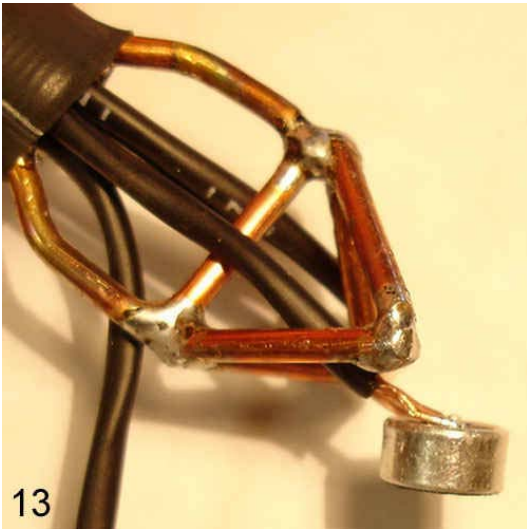
“Tin” the center tab; that is, apply a coating of solder to the center tab. Now solder the shield wire to that tab.

Do not pull on the shield wire attached to the tab. The tab is very fragile and is not really intended to be free standing.

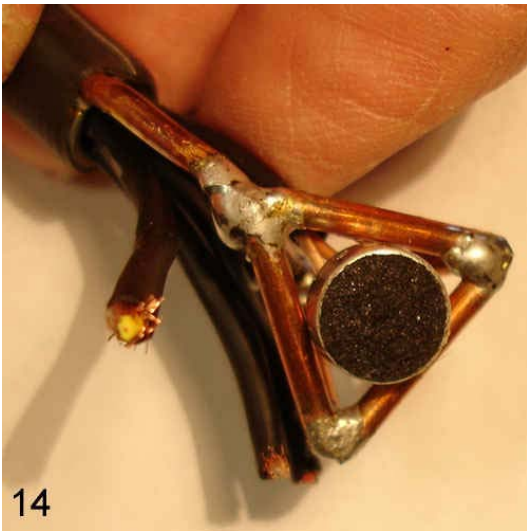
Let everything cool. Remove the capsule from the pliers.

12. Place your thumb on the face of the capsule and index finger on the terminals. Gently bend the wires so the capsule is almost parallel with face 1 of the tetrahedral without bending their connections to the capsule terminals.

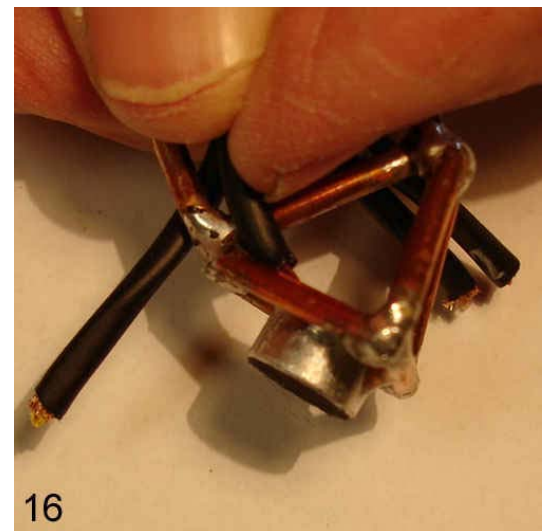




13. Gently pull the number 1 pair from the *bottom* of the pipe. If you need some capsule rotational alignment, twist the number 1 pair while pulling from the bottom; the capsule should follow the twist. If not, the 4 pairs of wires are probably not straight in the pipe. Straighten them (see step 8 above) and try again.



14. Before the capsule is seated on the tetrahedral, gently press the number 1 pair against one of the vertical sides of the U-frame. Do not pull tight; the shield wire and terminal 3 of the microphone capsule are fragile. If needed, push the number 1 pair from the bottom of the pipe for some slack. Capsule 1 is the LFU (left-front-up) capsule.

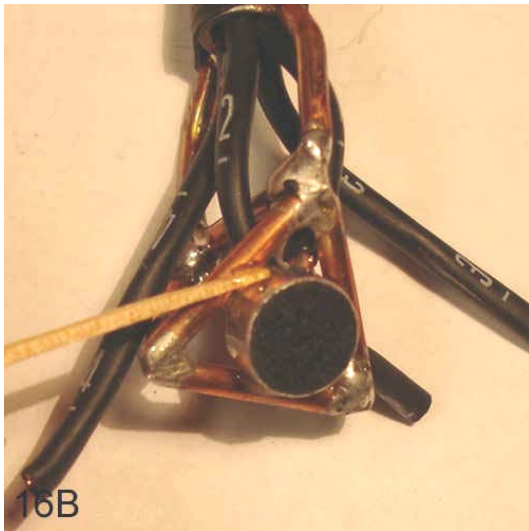


15-16. This is what the capsule should look like resting on all 3 edges of the tetrahedral face with the number 1 wire pair next to the corner solder joint.

THE NEXT PART WILL TAKE AT LEAST ONE-HALF HOUR PER CAPSULE.
I SUGGEST THAT YOU *NOT* MOUNT ALL 4 CAPSULES WITHOUT BREAKS.
THE NEXT SECTION WILL BE REPEATED FOR EACH CAPSULE.

The capsule should be resting on the 3 edges of a face of the tetrahedral and very close to its final position. The face of the capsule should be parallel to the face of the tetrahedral.

Thoroughly mix a small amount of fresh 5-minute epoxy. Be sure to mix enough so that if the amounts are not exactly equal, it will still cure properly. With the small end of a toothpick, roll a small amount on to the tip.



16B. Roll the epoxy with the toothpick into the valley formed by the capsule and its supporting wire. Do this for all 3 edges.

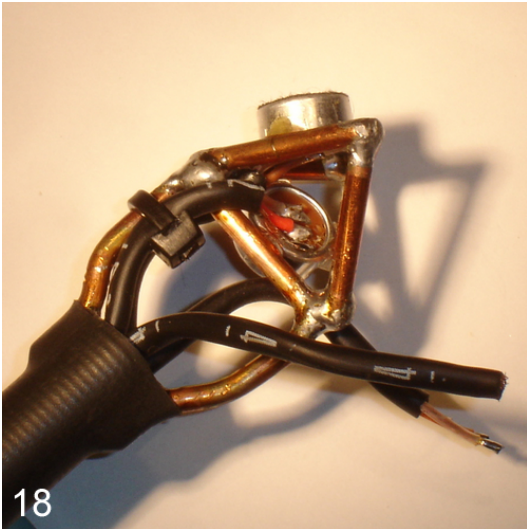
Grasp the tetrahedral and place your index finger or thumb on the face of the capsule. Carefully and accurately apply *slight* pressure to seat the capsule. Check that the capsule is centered and facing properly, flat to the face of the tetrahedral. Hold the capsule in this position for ONE HALF HOUR! DO NOT SHORTCUT THIS TIME!

NOTE: The epoxy may “set up” in 5 minutes, but typically it is not at “useable strength” for 8 hours and is not “cured” for 24 hours. Therefore, wait at least a couple of hours before going back to step 9 for the next capsule. It is difficult to cut out and reseal a misaligned capsule!

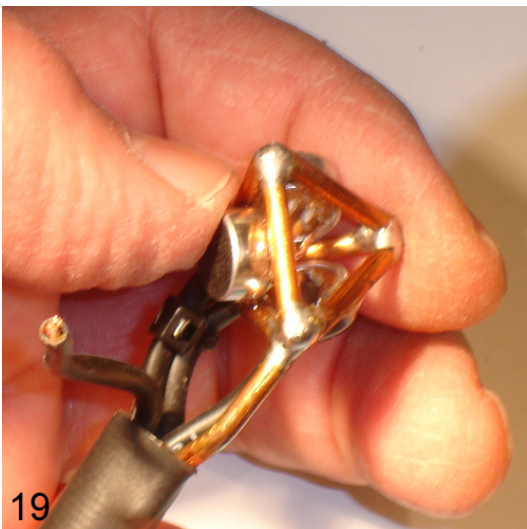


17. Capsule 2. Note the final routing of wire pair 2. Capsule 2 is the RFD (right-front-down) capsule.

Go back and follow steps 9-16B for capsule 2 with wire pair 2 threaded correctly through the tetrahedral.

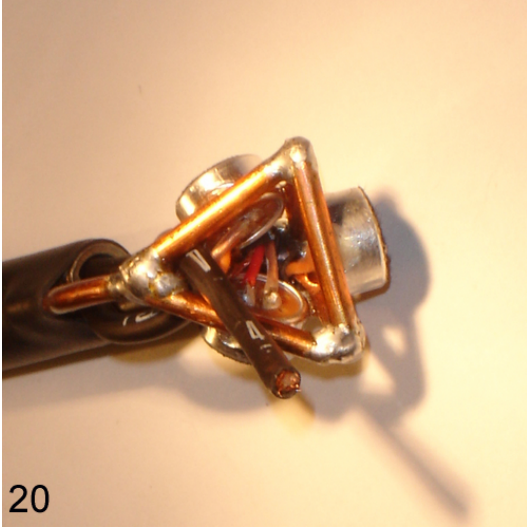


18. Capsule 2 in place with the epoxy set for a half hour. Before adding the tie-wrap, be certain the pairs lie next to the copper wire of the U-frame. If not, push more wire up from the bottom of the pipe. Pull the tie-wrap just snug.



19. Capsule number 3 faces *down*. Capsule 3 is the LBD (left-back-down) capsule. This is the ambisonic a-format order, not a clockwise rotational order. Also, note the routing of the wire for capsules 3 and 4 will come down the opposite side of the u-frame from pairs 1 and 2.

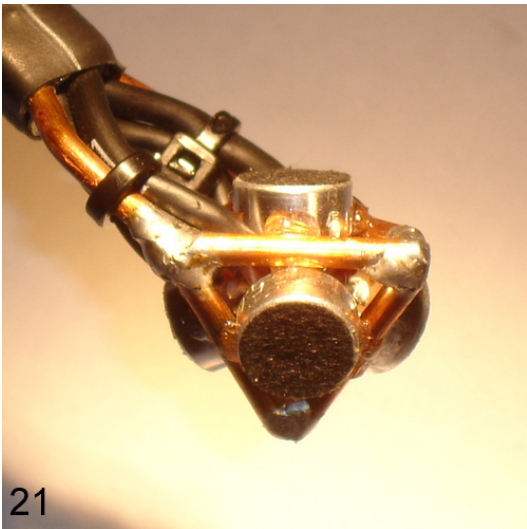
Go back and follow steps 9-16B except with wire pair 3 threaded correctly through the tetrahedral.



20. There is not much space for pair 4. Be sure the epoxy for the first 3 capsules is well set before continuing to the final capsule. Note the wire routing of the number 4 pair.

Go back and follow steps 9-16B except with wire pair 4 threaded correctly through the tetrahedral.

Be sure to keep the face of the capsule parallel to the face of the tetrahedral. Capsule 4 is the RBU (right-back-up) capsule.



21. After the epoxy for capsule 4 has cured, add the second tie-wrap. If more wire is needed to properly secure the wire, push it up from the bottom of the pipe. Again, just snug the tie-wrap. Note how the tie-wraps are oriented toward the inside of the frame.

Congratulations on completing the tetrahedral wiring.

The next step is to build the enclosure.

Rev. 20120127 – extensive editing, updated figures 17-21

Rev. 20131116 – substitute AUI Audio capsule for discontinued Panasonic capsule