

# Portable DIY Headphone Amplifiers

By: Alex Gurga

## **Motivation**

The motivation of this project is to produce a portable, compact, and powerful amplifier that can run a high end pair of headphones, in this case a pair of Grado SR-125's. Having had very little experience with building electronic circuits I decided to build a simple cheaper amplifier at first and work up to a more powerful and expensive amplifier after some practice.

## The Amplifiers

### CMoy

The first amplifier built was a very popular, simple DIY project called the CMoy, which was originally based on a circuit designed by Chu Moy.



The CMoy is very popular among people new to DIY projects because it is made of very cheap components, can be put together easily by almost anyone, and has surprisingly long-lasting yet powerful performance. The particular CMoy that was built was a JDS labs Bass Boost CMoy v2.02. The circuit is designed around a highly efficient dual channel Texas Instruments OPA2227PA. The Texas Instruments OPA2227PA is a unity-gain MOSFET based dual channel operational amplifier with a wide bandwidth and low quiescent current making it ideal for portable devices. In order to reduce size and weight a Texas Instruments TLE2426CLP rail splitter is used to produce a “virtual floating ground” so that both channels can be run on only one 9V battery. The amplifier, when built, has a theoretical gain of about 6, with an additional bass boost circuit with a gain of 9. The finished product is typically installed in an Altoid’s mints tin giving it a very recognizable and unique character.

### **mini3**

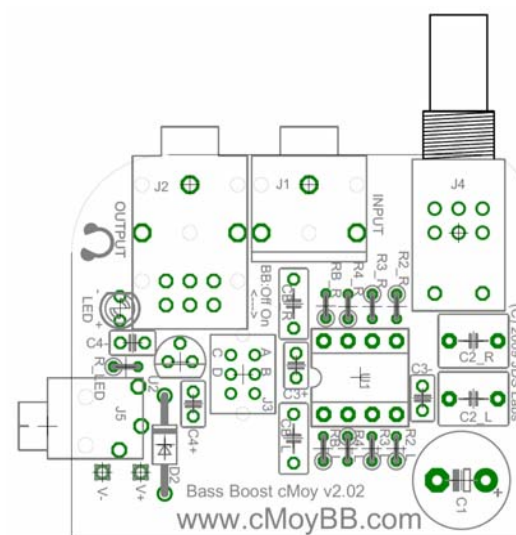
The second amplifier built was a slightly more complicated, higher performance amplifier called the mini3. The mini3 uses a slightly different design that utilizes a much higher speed, wider bandwidth opamp based around a Texas Instruments AD8397ARDZ: a slew rate of 53 V/ $\mu$ s vs the 2.3 V/ $\mu$ s of the CMoy, and a bandwidth of 69 Mhz vs the 8 Mhz of the CMoy. The mini3 produces a much more linear and accurate frequency response in a much sleeker more attractive package.



The basic design of the mini3 is very similar to the CMoy, except that it has a charging circuit built in for using a high capacity nickel metal hydride battery.

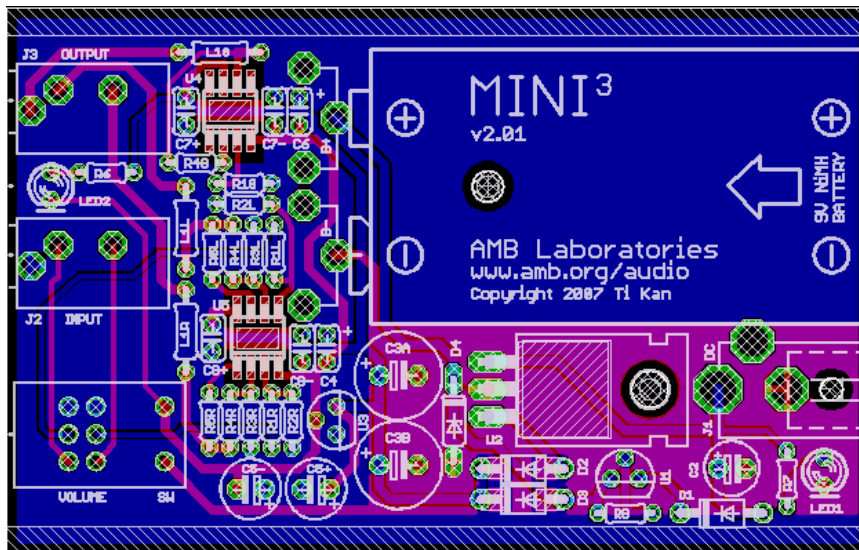
## Construction

A predesigned pcb was provided by JDS Labs, and parts were purchased from Mouser and Digikey.



The parts cost about \$50 US and took around an hour to fully assemble the pcb, including the casing the project could easily be completed in around 2 hours. It is easy to see why the CMoy is so attractive to new DIYers in that it is so cheap and easy to make.

The mini3 was significantly more expensive and complicated to build. The mini3 was also build off a predesigned pcb provided by AMB labs, and parts were ordered from Mouser.



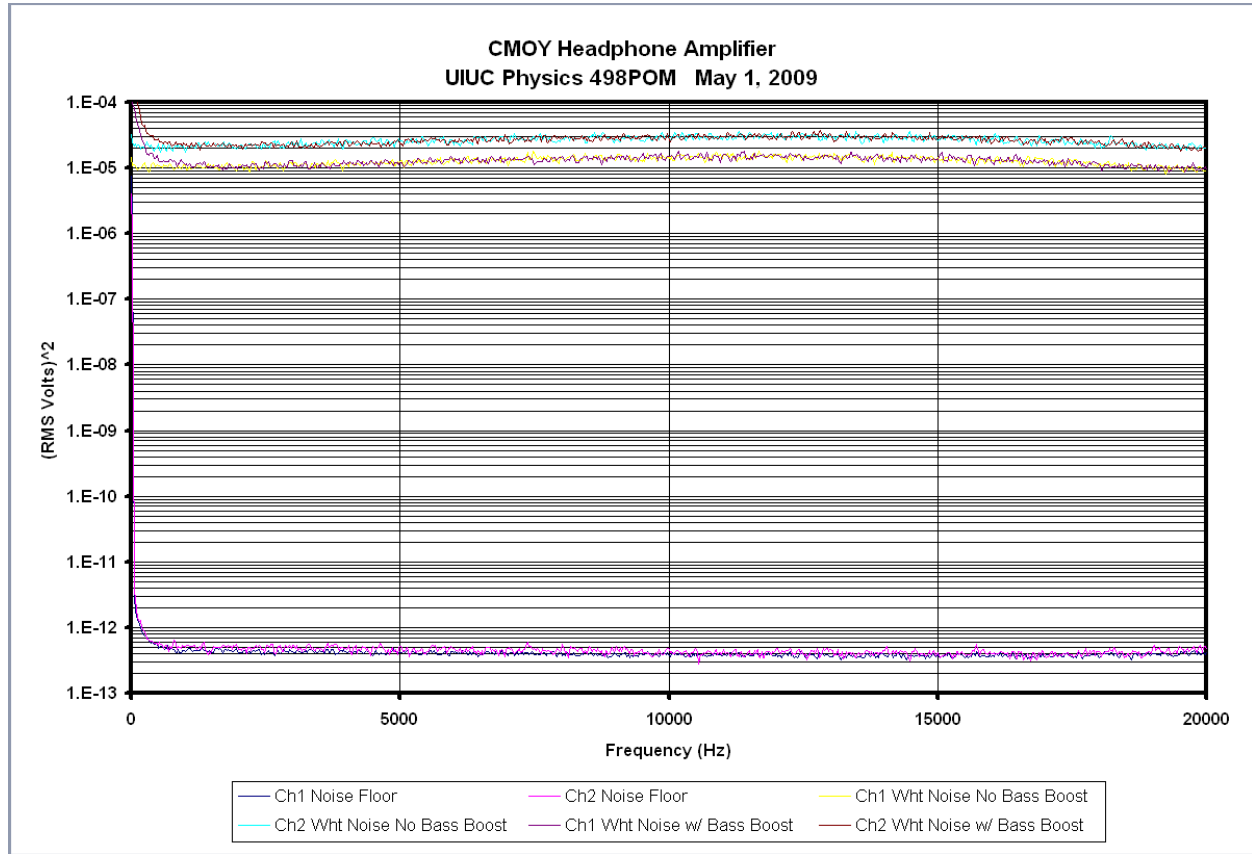
The parts cost about \$100 and took around 3-4 hours to assemble. The opamp and ground channel chips were SOIC and were significantly more difficult to attach to the board than the thru-hole based chips used in the cmoy. The very small format also makes them very susceptible to electrostatic shock. During construction the first AD8397ARDZ was destroyed by electrostatic shock and needed to be replaced.

## Performance

### CMoy

Upon first listening the CMoy has an astounding output level and clarity for such a simple design. When set to the highest volume the headphones are so loud they can be heard from across the room. For fear that such high volume could be dangerous to one's hearing the sound pressure level was measured. The amplifier was attached to a Creative MuVo V100 mp3 player, an mp3 player with output typical to other small portable players. The song "Get up offa that thing" by James Brown was used as an example of a typically "loud" song. With a calibrated sound pressure level meter and a piece of rough to enclose the

sensor against the headphone earpiece a sound pressure of 122dB was measured! Which, if kept at this level could easily damage one's ears. Next we measured to noise floor and linearity of response to white noise of the device using a WavTek function generator and a Heward Packard frequency analyzer.

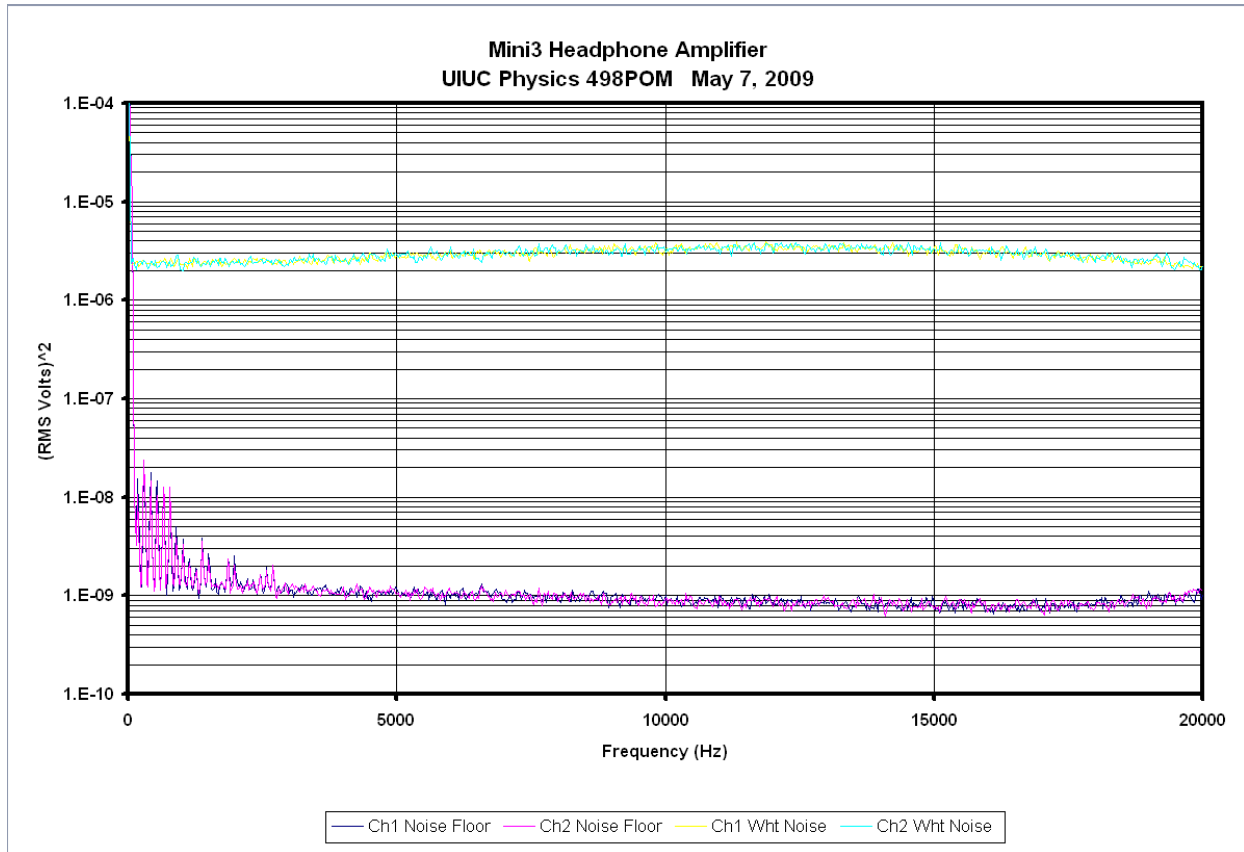


The noise floor is very low around 5E-13 V Rms, and the frequency response is surprisingly linear, the spike on the low end is due to the additional bass boost.

### **Mini3**

The sound pressure level measure for the mini3 was 105 dB, compared to the unamplified level of 100 dB. The gain setting for this player was only 2x instead of the 6x of the CMoy, so this is not too surprising. At maximum volume however the mini3 sounds much cleaner to the ear and has a much

wider soundstage. The noise floor and white noise measurements were surprisingly high and it is believed that they were false readings, because afterwards the voltage of the battery was measured to only be about 4V. More tests need to be made to obtain a more accurate reading.



The readings would indicate that the CMoy should sound a lot better than the mini3, but to the ear the mini3 sounds much cleaner and warmer. More tests must be done to confirm whether the measured results are erroneous or not.

## Conclusion

Both amplifiers are great projects for beginning DIYers and have fantastic performance for the price and difficulty of constructions. Similar consumer pocket amplifiers cost upwards of 300-500 dollars for

similar performance, and due to the massive online community of DIYers one might arguably say that in terms of technical support the DIY kits are much more reliable.

#### Special Thanks

Ti Kan and AMB Lab for the mini3 related materials.

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