Do-it-Yourself cMoyBB Assembly Guide

Contents

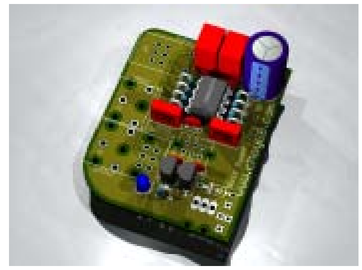
PROJECT OVERVIEW 1

ASSEMBLY GUIDE 4

MODIFICATIONS 8

Project Overview

Founder's Remarks



The concept of the Bass Boost cMoy began in the summer of 2006 when I took an interest in DIY audio. The original cMoy design from 1998 was nothing new. In fact, I already owned a cMoy I had purchased from eBay. But as an electrical engineering student, I was intrigued by potential modifications of the simple circuit and wanted to increase the subpar bass response of my Sennheiser HD-280 Pro headphones.

After spending days reading tutorials, message boards, shopping for parts, and then tweaking a cMoy on a breadboard, I spent more than eight hours constructing my first hand built cMoy on protoboard. It didn't work. I spent another eight hours assembling a second (and functional) cMoy, later realizing I had forgotten just one wire on each channel of the first amp. In all, it took over 25 hours to build the same amplifier many others before me had built over the previous eight years.

Some months later, the first Bass Boost cMoy was born on a messy breadboard. Thrilled with the result, I decided to produce a few nicer versions of the amplifier for myself on professionally printed circuit boards and share the great circuit with fellow audio enthusiasts. The cMoyBB has since found owners in more than 50 nations around the world.

The cMoyBB can be electrically completed in under 30 minutes, saving you many tedious hours over building a regular cMoy. More importantly, the cMoyBB cannot be matched by other cMoys in terms of audio quality.

Why DIY?

It's important to me to promote engineering creativity and progress, thus, JDS Labs upholds DIY tradition by making the cMoyBB available to everyone. Music, or audio in general, is a subjective topic. I greatly prefer the sound of the cMoyBB over other entry-level amplifiers. Still, you may wish to experiment with different resistors, capacitors, jacks, enclosures, or something more exotic. We suggest just a few alternative components in the BOM, but building the amplifier yourself gives you the freedom to build a unique, top-notch cMoy with practically an unlimited number of options.

Will building a cMoyBB myself save money?

The cMoyBB is a high-end version of the cMoy. It was not meant to be cheap. A cMoyBB built to standard specifications will easily exceed $50 USD, plus the cost of any tools you may not own (not to mention your valuable time and labor).

DIY headphone amplification is for those who possess the interest and/or knowledge to build their own amplifiers. In other words, this project is not intended to save you money. It is always fastest and easiest to buy a preassembled amplifier.

Where are the PCB Gerbers?

The cMoyBB cannot be properly reproduced without its custom printed circuit board (PCB). Achieving proper signal characteristics and decoupling is essential to the amplifier's performance. These features **cannot** be reliably implemented with protoboard or homemade, single-layer PCBs. The cMoyBB's PCB has undergone numerous revisions since 2007 and analog signal integrity analyses. Amateur PCB designers usually lack the knowledge to design a PCB with equivalent performance. If we were to release the PCB files, cloned versions of the cMoyBB would undoubtedly produce inferior sound quality and tarnish the amplifier's excellent reputation.

And as explained above, it wouldn't be worth anyone's time to try to copy the circuit by hand. The cMoyBB v2.03 PCB is priced competitively (barely more than protoboard) and is absolutely necessary to achieve great sound quality. For these reasons, we choose not to release the board files.

Skill and Knowledge Prerequisites

Although this guide should single-handedly provide you with the necessary information to build a cMoyBB, I highly recommend browsing through Tangent's cMoy tutorial and Chu Moy's original article. The cMoyBB is a derivative of the original cMoy design. Consequently, I will not bother repeating Tangent's exceptional work. If you are not already skilled in soldering, definitely check out Tangent's tutorial videos and practice before you begin.

Usage Policy

Effective October 2012, the cMoyBB schematic is released under the CC BY-SA 3.0 license. Please note that "cMoyBB" is a trademark of JDS Labs. We ask only that derivative projects be released with a new project name, and in accordance with the license requirements.

Assembly Guide

Required Tools

• Soldering iron with a small tip
• Rosin core 60/40 solder (0.032" or thinner highly suggested)
• Diagonal cutters
• Small flathead screwdriver
• 6-32 (imperial) hex screwdriver
• Heavy duty 1/4 inch hole punch (recommendations below)
• Hot glue gun and hot glue, or other method of eletrical insulation
• Dry-Erase marker
• High concentration Isopropyl alcohol (> 94%)

Pre-Assembly

In addition to the reference images on this page, you will need to refer to the downloadable Bill of Materials and supporting documents available from the JDS Labs item page:

- Download: Bill of Materials
- Download: Schematic
- Download: Enlarged View of PCB
- Download: Enclosure Cutout Pattern

We recommend that you review the entire instructions guide before beginning, especially if you plan to omit, bypass, or modify any features.

PCB Assembly (15 to 45 minutes)

Solder after each step, then trim off excess leads with diagonal cutters.

1. Begin by mounting the 8-pin DIP socket on the board. Be sure to match to socket's orientation notch to the label on the PCB. Bend two adjacent socket pins on the bottom side of the circuit board to keep it in place.

2. Place capacitors C3+, C3-, and C4. These capacitors are non-polar, i.e., they can be inserted in either direction. Optional diode D2 should also be placed at this time (observe polarity!). Capacitor C5 should only be installed if also using optional component U3.

3. Install all resistors vertically as shown in page 6 figure:

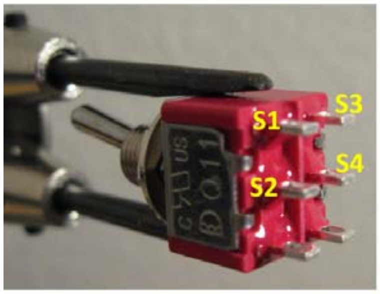
   R2_L and R2_R
   R3_L and R3_R
   R4_L and R4_R
   RB_L and RB_R
   R_LED (or R7 and R8)

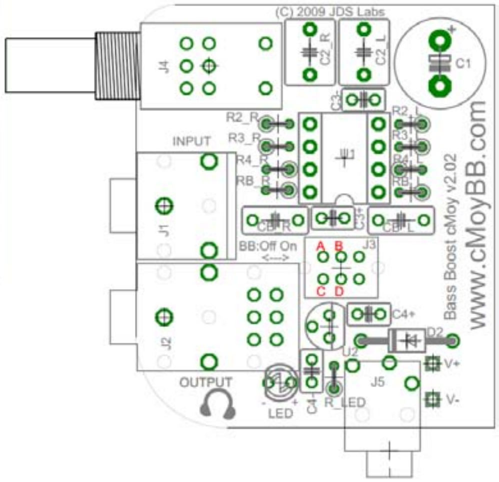
   For cMoyBB v2.03R, also place:

   R1
   R8
   D3, D4, D5

4. Place capacitors C2_R, C2_L, CB_R, and CB_L. These capacitors are also non-polar.

5. Mount the bass boost toggle switch in location J3. Direction is unimportant. Hold the switch in place and carefully bend adjacent pins as in step 1. Alternatively, you may use four short 22 gauge wires to connect an enclosure mountable switch as shown below, or a bass boost control potentiometer as described in the Modifications section.





Connect:

S1 <----> A
S2 <----> B
S3 <----> C
S4 <----> D

6. Push the Texas Instruments TLE2426CLP IC into location U2 (and optional second TLE2426CLP into U3). The center pin will bend easily and allow you to slide the component into place.

   For cMoyBB v2.03R, insert an LM317 regulator into U4.

7. Place capacitor C1. Electrolytic capacitors are polarized; the longest lead is positive (+). If you use an especially tall capacitor (14mm or taller), make sure it will fit in the enclosure before soldering. The capacitor may be rotated 90 degrees if height is a problem.

8. Insert all jacks: J1, J2, J4, J5. The extra six pins on the STX-3100-9C audio jack (component J2) are sensitive to heat damage. Solder each pin in under 1.5 seconds, with 5+ second cooling periods between soldering each pin.

9. Place the 5mm LED in spot D1, noting polarity. Bend the LED forward 90 degrees so that it is aligned with the DC jack. It will be helpful to bend the LED's pins before soldering. LEDs are also sensitive to heat damage. Solder quickly.

   If assembling cMoyBB v2.03R, insert a 3mm LED vertically into D2 (do not bend).

10. Insert the red lead of the 9V battery connector into terminal V+ and the black lead into terminal V-. If you wish to braid the battery connector wires, do so before attaching the connector to the PCB.

    Extra holes marked "18V" are only to be used with dual battery connectors. See Modifications section.

11. Insert the OPA2227PA operational amplifier (or other opamp) into the DIP socket, once again observing socket orientation.

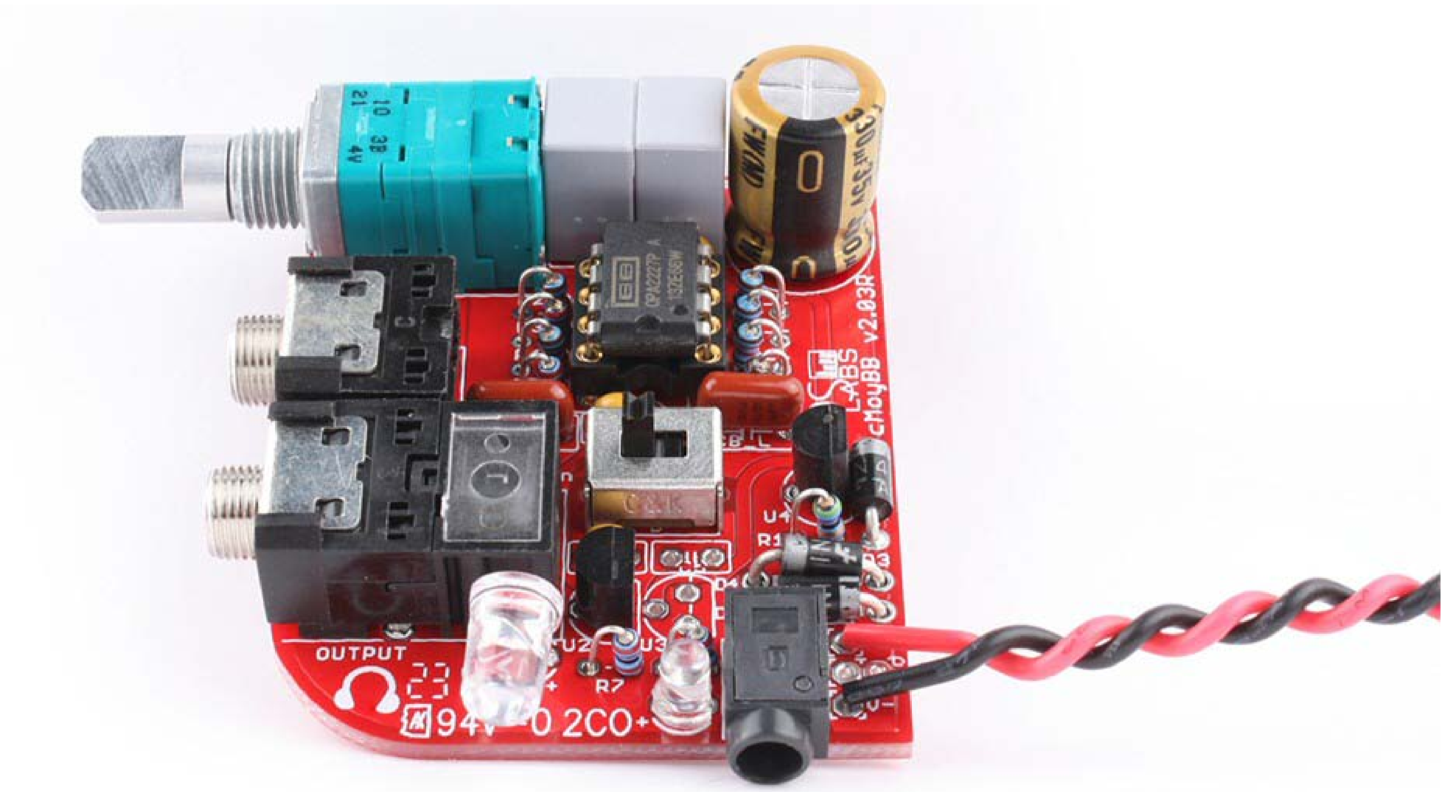
Post-Soldering Tests (5 to 15 minutes)

Now is a good time to test your new cMoyBB. Connect a new 9V battery and a cheap pair of headphones to the amp. Barely turn the volume knob on and check for obvious faults: Ensure you hear silence from your headphones and that no chips or components are overheating (everything should be cool to the touch). Engage and disengage the bass boost switch and check that no problems arise.

Assuming this preliminary test passes, connect the amp to a cheap source to verify its full functionality. Once you are satisfied, disconnect the battery while the amplifier is on. This will discharge the capacitors so that no energy is stored while mounting the PCB in the enclosure.

DC offset can optionally be verified by measuring the voltage at each of the output channels with respect to the audio ground. Offset should not exceed 20mV with bass boost turned on. Typically, DC offset for the cMoyBB with an OPA2227PA opamp is below 4mV with bass boost on and below 2mV with bass boost off.

Once you have a working amplifier, you should clean the PCB. Use rubbing alcohol and an old toothbrush to scrub excess flux from the bottom of the circuit board. Refer to Tangent's video tutorials for help. Failure to clean the PCB can eventually lead to corrosion of the PCB's 74 soldering pads.



Casing Assembly (5 to 30 minutes)

See Also: Archived cMoyBB Casing Video

1. Print the enclosure pattern and set an Altoids tin atop the printout. Use a Dry-Erase marker to mark approximate jack locations and the edge of the enclosure's lid.

2. Punch holes at the marked locations with a hole punch. Vertical heights are not critical, but are provided for reference in the image at right. Ensure the holes will not interfere with the lid (remember to account for the audio jack nuts). Holes for the audio jacks, the LED, and the DC jack should require a single punched hole. The volume potentiometer hole will need to be enlarged by punching multiple holes. This unsightly hole will be hidden by the volume knob.

3. Insulate the bottom of the PCB to prevent shorts against the tin. For example, apply hot glue to various spots on the bottom of the PCB, but avoid gluing soldering pads. Other insulation ideas include: foam, plastic, cardboard, or thick layers of electrical tape.
4. Slide the assembled PCB into the tin, potentiometer first and DC jack last. Even if the holes and jacks line up well, the PCB will need to be pushed into place with light to moderate force.

5. Screw the audio jack nuts onto the threaded 3.5mm jacks (J1 and J2).

6. Insert the LED grommet (see tip below).

7. Attach a piece of sticky sided foam inside the tin as a battery cushion, then connect a 9V battery.

8. Shut the enclosure lid and position the volume knob onto the RK097 potentiometer shaft. Tighten the knob's 6-32 hex screw.

Casing Assembly Tips

You may find it difficult to punch holes in the mint tin with a regular 1/4" paper hole punch. For best results, use a heavy duty 1/4" hole punch such as:

- OfficeMax® Padded 1/4" Hole Punch
- Fiskars® 1/4" Hole Punch

Fiskars hole punches are extremely durable, but the punch retaining clip must be modified or removed for use with this project. **2013 Update:** Recent Amazon reviews of the Fiskars hole punch indicate a possible change in tool quality since we first recommended this hole punch in 2009. Success may vary with this tool!

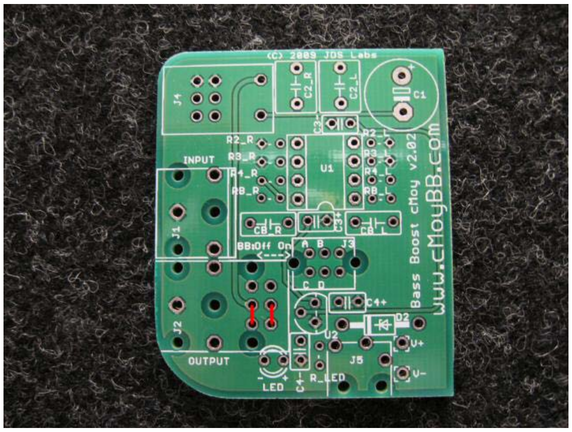
Do not use the washer or nut with the Alps RK097 potentiometer. The input, output, and DC jacks are arranged so that the amplifier will already be securely positioned without the volume potentiometer. The RK097's washer & nut are too large for the tin's lid to close easily (though it is possible). As previously mentioned, the potentiometer's hole and threads will be covered up once a volume knob is attached.

It is usually possible to push the LED grommet in place. If not, trim off one of the two thickest plastic "legs." The grommet should still stay in place.
DIY Modifications - v2.03

Modifications

Feature Substitutions and Omissions

- To omit the DC jack, short the pads of J5 that connect to the symbol "_/_"
- An STX-3100-3C audio jack can be used in place of the STX-3100-9C jack for part J2. The auto on/off feature must be bypassed by shorting all unused pins of J2 as pictured at right.
- The internal bass boost switch can be substituted for other DPDT switches or a 50kΩ potentiometer. Connection diagrams and details are given below.
- To disable bass boost, short the CB_L and CB_R terminals, independently.
- Diode D2 is reserved for reverse and over-voltage protection and is not required. To omit D2, leave its spot empty (do NOT short the pins).



Gain Adjustment

You may wish to set a gain not listed in the Bill of Materials. Flat-response gain of the cMoyBB can be calculated as follows:

Gain (voltage) = $A_v = 1 + ({}^{R}{}_{4}/_{R3})$

Gain (dB) = $20*\log(A_v)$

Headphone Impedance	Suggested Gain (Av)	Number of Batteries	Virtual Ground IC's
8-40 ohms	2-3	1x9V	U2 and U3
41-120 ohms	4-6	1x9V or 2x9V	U2
121-600 ohms	6-8	2x9V	U2

Higher gain creates a more stable opamp circuit. Most opamps are stable with a gain of 3+. If you encounter unexpected behavior while trying other opamps, try a higher gain.

cMoyBB Frequency Response Calculator - This Java applet simulates frequency response of the cMoyBB based on all component values. Gain is calculated in decibels (dB). The "Bass boost OFF" curve is fully applicable to a standard cMoy circuit.

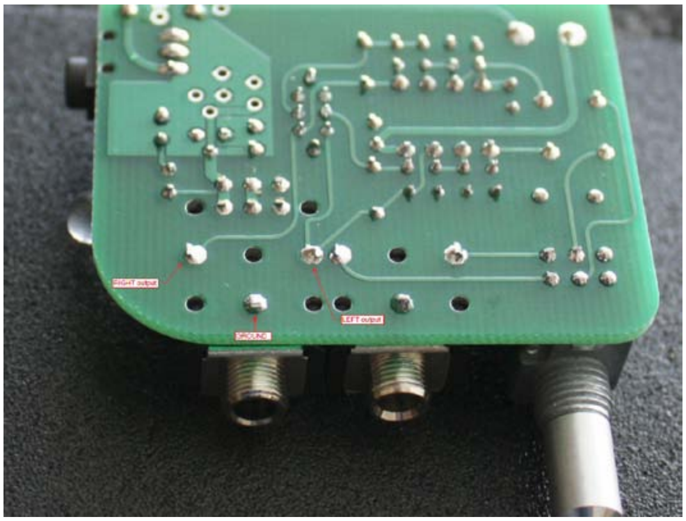
Optional Modifications

DC Coupling / LOD Attenuation:

Capacitors C2 serve to AC couple the audio signal to the operational amplifier. AC coupling eliminates potentially dangerous DC offset from the source at the expense of audio quality. Additionally, this modification improves channel balance and noise at low volumes. DC coupling is highly recommended when using line-level input signals as it provides sufficient input attenuation to prevent overdriving of the opamp when using a weak battery.

To use DC coupling, replace C2_L and C2_R with 330 ohm resistors (or use 1.6k for LOD attenuation).

It's good practice to measure source DC offset before using a DC coupled amplifier. DC offset at either channel should not exceed 20mV with bass boost on. Offset can be measured with a voltmeter set to millivolts: Place the black probe on the output jack ground and touch the red probe to the left or right output.



Resistors

Use 1/8W resistors instead of 1/4W. Physically smaller resistors will reduce lead length, for improved performance.

Capacitors

Try WIMA capacitors for C2_L and C2_R, and any of the more expensive varieties for C1. See Bill of Materials.

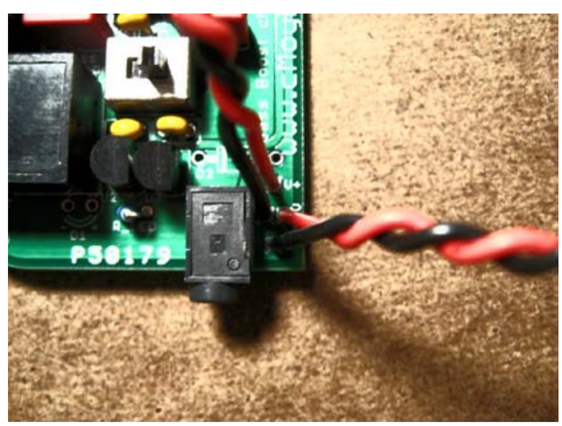
Virtual Ground

The cMoyBB is normally assembled with a single Texas Instruments TLE2426 "rail splitter" placed in spot U2. These highly accurate rail splitters have been used in CMoys since 1998 for their superior performance over resistive voltage dividers. The majority of users will find listening satisfaction from a single TLE2426, but in some cases (very low impedance headphones played at very high volumes), more current is demanded than any CMoy can continuously supply. If you require even higher volumes, a second TLE2426 can be added to double current handling.

This modification has a few disadvantages:

• Battery life is reduced by 10-15 hours (~50%)
• Higher cost
• Little to no benefit with headphones above 64 ohms
• Not recommended for use with dual 9V batteries
• Prolonged listening at higher volumes causes hearing damage!

To install dual rail splitters, place a second TLE2426CLP in spot U3 and use a 0.1uF ceramic capacitor for C5.



Dual 9V Batteries

Increasing the supply voltage to 18V enables higher volumes when driving high impedance headphones (typically 64 ohms and above). Two batteries in series will drain somewhat faster than a single battery. This modification also adds weight to the amplifier and adds slight difficulty when changing batteries due to the very tight fit. Most people with 120 ohm headphones and less are pleased with a single 9V battery, therefore, we only recommend using 18V if you find 9V to be insufficient.

Two pads labeled "18V" reside between the normal V+ and V- battery pads. To install dual battery connectors, connect a black lead from one 9V connector to an "18V" pad, and the red lead from another 9V connector to the remaining "18V" pad. You will be left with one red and one black wire. Connect these wires to V+ and V-, respectively.

Dual Battery Tip: When using dual batteries it's extremely helpful to use a thin profile "Economy" 9V battery connector for the second battery, rather than another (very thick) "Premium". Changing batteries is much less troublesome with this configuration. Suggested 9V connectors are listed in the Bill of Materials.

Bass Boost Control Knob

Omit the bass boost switch and both R_B resistors (leave them out!). Use four *short*22 gauge wires to connect pins A, B, C, and D to a 50kΩ potentiometer. This results in adjustable bass boost via a control knob. Terminal connections for Alps/Vishay and Panasonic 50kΩ potentiometers are given in the diagrams below. If bass boost is found to be too strong, install 51k resistors in RB_L and RB_R to reduce the intensity by a factor of two.

This modification is rarely recommended due to higher cost and possibly decreased performance. Using long wires in this part of the circuit negatively impacts THD and the SNR of the amplifier. Also, most users ultimately turn the knob to 0 or 100%, thereby defeating the purpose of the modification. Best performance and value is attained from the standard toggle switch.

Tip: Try to minimize wire length. Unnecessarily long wires will add inductance and capacitance to the feedback loop, potentially causing unwanted noise or oscillation.

Connect:

(G2 & O2) <---> A
I2 <---------------> B
(G1 & O1) <---> C
I1 <---------------> D