Make a Sweet Portable Guitar Amp

By mdgrover in CircuitsElectronics

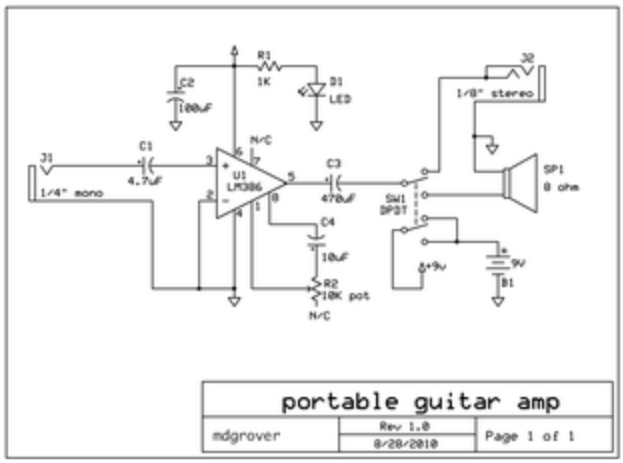
Introduction: Make a Sweet Portable Guitar Amp

Inspired, by gum!
The inspiration for this project was actually two-fold. First, I needed to make a simple, portable guitar amp that would work with an electric bass guitar as well as an acoustic six-string (with a pickup), and could be played through a speaker or headphones. I knew I had all the components needed for a basic "LM386" audio amplifier, but the second part of the inspiration didn't hit me until I was looking for an enclosure for the project. I had a few empty Eclipse gum "bottles" laying around, and upon quick inspection, I realized that the opening at the top was 2¼" (60mm) - exactly the size used by many standard PCs for the internal speaker. The goal from then on was simple - make the entire 1-chip amp fit into the container underneath the speaker, with the lid threaded on over the speaker to hold it in place.

Skills and tools required:
I'm assuming for this project that the builder has some basic electronics experience such as breadboarding simple circuits, wiring and soldering. Tools needed for the electronics assembly are the usual hand tools - wire cutters, needlenose pliers, a low-wattage soldering iron and some rosin-core solder. A helping-hands vise setup would be great if you have one. Not a lot of mechanical skill needed here, just some drilling and light finishing which we'll get to in Step 5. A power drill and a few smaller bits (up to about ¼") will be needed, and if you've never used one before, a tapered reamer is the perfect tool for getting all the jacks and switches to fit perfectly through the sides of the plastic container.

The components required are included in Step 1. You may have a few of them lying around, but even if not the whole list could be purchased for under $10.

Step 1: Parts and Schematic



Parts list:
B1 - 9 volt battery clip and battery
C1 - 4.7µF 16v capacitor
C2 - 100µF 16v capacitor
C3 - 470µF 16v capacitor
C4 - 10µF 16v capacitor
D1 - green diffused LED (just about any color/type will work)
J1 - ¼" (6.5mm) mono jack (guitar input)
J2 - ⅛" (3.5mm) stereo headphone jack (headphone output)
R1 - 1kΩ ¼-watt resistor
R2 -10kΩ ½ watt potentiometer
SP1 - 8Ω ½ watt speaker (2¼" diameter, from an old PC)
SW1 - DPDT "on-off-on" mini toggle switch
U1 - LM386N-1 low voltage audio power amplifier IC

Misc. - breadboard and breadboarding jumper wires (for optional Step 3), hookup wire (small-gauge stranded), small perfboard, solder, knob for R2

Sources:
The only really critical parts here are SP1 for it's diameter and SW1 because of it's special "on-off-on" function.

For SP1, you just need a simple 8Ω speaker - around ½ watt, and exactly 2¼" (60mm) in diameter. I found several of these in my parts box that were pulled from old PC's so it seemed to be a standard size for that application. If you don't have one handy, here are a few places to find them:
- Jameco #135765 (currently $1.59)
- Jameco #10840 (currently $1.95)
- All Electronics #SK-285 (currently $1.25)

For SW1, this type of switch can be easily found. You want to find a mini or sub-mini sized switch with solder lug (not PC-mount) terminals. Here are a few places I found a suitable model where I typically look for parts:
- Radio Shack #275-664 (currently $4.99 each)
- Jameco #21952 (currently $1.55 each)
- All Electronics #MTS-120PC (currently $1.50 each)
- Futurlec #DPDT101 (currently $0.90 each)

The rest of the components should be pretty easy to find wherever you usually buy parts, but here are some links to Futurlec:
B1 - (battery clip) #9VBATTCLIP (currently $0.10 each)
C1 - #C0047U50E (currently $0.05 each)
C2 - #C100U16E (currently $0.10 each)
C3 - #C470U16E (currently $0.12 each)
C4 - #C010U16E (currently $0.05 each)
D1 - #LED5R (currently $0.08 each)
J1 - #P065SCK02 (currently $0.75 each)
J2 - #P035SCK02 (currently $0.50 each)
R1 - #R001K14W (currently $0.10 each)
R2 - #POT10K (currently $0.55 each)
U1 - #LM386N-1 (currently $0.75 each)

My personal recommendation would be to bundle all the parts you can from Futurlec. It takes a few extra days to ship (from Thailand) but the prices are unbeatable. Their electrolytic capacitor pack (#ELEPACK) includes 100 pieces for $3.95. I can't say for sure what values are included in every pack, but the four values needed for this circuit were included when I bought one. They also have a 300 piece resistor pack too (#RES14WPACK) for $2.95, which makes them less than a penny each. Probably don't need that for this project, but it's a good way to re-stock your parts bins.

The schematic:
At the heart of course is the LM386 amplifier, which delivers decent sound with just a few external components. I used the "N-1" version of the chip. This amp delivers 250-325mW of output power, which is plenty for this application. (You could drop in an N-3 or N-4 version pin-for-pin to get either 700mW or a full watt of output power, but you'll need a speaker rated for the additional power - and I would not recommend using the amp for headphone output).

The circuit is designed to deliver the input signal from the guitar via J1 through capacitor C1 into the LM386's non-inverting input at pin 3. The inverting input at pin 2 is connected to ground along with the chip's ground pin 4. The audio output is delivered through capacitor C3 into DPDT switch SW1 which simply directs the amplified audio signal to either speaker SP1 or the headphones connected to J2. The other pole of SW1 acts as a power switch to the circuit, connecting the positive lead from 9V battery B1 to the chip's voltage source pin 6 as well as to the LED power indicator D1 through current-limiting resistor R1. Filtering capacitor C2 sits across the power supply rails. Finally, the RC series circuit of capacitor C4 and potentiometer R2 provides variable gain control for the amp. I found that with these values, I could get an output range from a really clean output into the headphones all the way up to a nice distorted overdrive into the speaker. If you need to experiment with any component values with your particular instruments, those will be the ones. I found with the guitars I worked with that it took a combination of guitar volume knobs and the amplifier's gain knob (R2) to get the right sound level, especially for comfortable headphone listening.

Step 2: Preparing the Off-board Components

You'll need to solder some leads onto the off-board components (J1 and J2, D1, R2, SP1 and SW1) in order to bring them into the breadboard (if you do Step 3), and you'll be able to use the same leads when you build the permanent circuit onto a perfboard. I strongly recommend using small-gauge stranded hookup wire, as it will be a lot more flexible when stuffing everything into the plastic enclosure. In my first prototype I used solid hookup wire on SW1 (since it already had leads soldered to it from some other project) but it made getting things into the enclosure a real pain - some leads even broke off and had to be resoldered.

Make sure to leave a good length of wire on SP1 since it will need to move out of the way in the finished project in order to change the battery. In my circuit (as you can see below), I actually kept the two-pin female header that was already connected to the old PC speaker I used, and then connected it to the circuit with two breadboard jumper wires. Pay special attention to SW1 - you'll actually connect both terminals of the power switching pole together so that the circuit is energized whether you are connecting the speaker or the headphone jack. Also note that for J2 you'll need to solder the two stereo terminals together, otherwise you'll only be able to hear the amp in one ear. Finally, make sure to solder your two leads onto the center and right terminals of potentiometer R2, to make sure the gain increases with a clockwise turn. See the detailed pictures below.

Step 3: Breadboarding the Circuit (optional)

Standing up the circuit:
I have found that even for a familiar circuit, breadboarding it first is always well worth the time. It gives you the opportunity to test everything end-to-end and then easily swap out some component values to tweak things as needed. This is where some of those "happy accidents" happen that you sometimes miss when you reach for the soldering iron right away. In this step I'll introduce the components and the schematic and then map out the breadboard version of the circuit.

There's nothing really special or complicated about the breadboard layout below. Note mostly the orientation and pinout of the LM386 as you hook up the circuit, and of course watch the polarity of all four electrolytic capacitors and the LED. If you've already prepped all the off-board parts with leads (from Step 2) just make sure to twist the free ends tight and then tin them up with a little solder to make it easier to insert them into the breadboard.

Once you have the circuit up and working, plug in a guitar and see how the gain control (R2) and the guitar's volume control(s) can work together to get the sound you want from both the headphones and the speaker. Go easy on the gain, especially the first time you connect your headphones - the output may be a little more powerful that you'd expect.

Step 4: Circuit Assembly

I found that a small piece of perfboard (about 1" x 1¾") provided plenty of room to build the circuit and still fit it into the container. As with the breadboard layout, there's nothing really special or complicated about the final circuit assembly. Do try to keep capacitors C1, C3 and C4 placed as closely to U1 as possible. The only other thing I might change the next time I build on of these would be to lay the four capacitors down horizontally on the perfboard to provide a little more clearance once inside the container. Mine were mounted vertically, and they are not very tall, but every little bit of space counts. You may want to use an 8-pin DIP socket for U1, but if you solder quickly with a low-wattage iron you should be fine. You may need to add a piece or two of hookup wire, but most of the circuit can be wired "point-to-point" using the legs of the components. As with the breadboarding step, watch the orientation of U1 and the polarity of all four capacitors and the LED. My speaker already had a 2-pin female socket attached to it, so I soldered a 2-pin 0.1" spaced header to the board to connect it to. This has been really helpful with getting the speaker out of the way when changing the battery.

Once the circuit is completely assembled, plug in a guitar and see how the gain control (R2) and the guitar's volume control(s) can work together to get the sound you want from both the headphones and the speaker. As I said in Step 3, go easy on the gain, especially the first time you connect your headphones - the output may be a little more powerful that you'd expect. Make sure the LED lights up in both switch positions, and you are ready for the final assembly step.

Step 5: Final Assembly

Before stuffing everything into the gum container, I cut out a piece of thin cardboard the same size as the perfboard and used a few dabs of hot glue to attach it to the underside of the perfboard. This is to keep the circuit from shorting out on any of the off-board components in the container, especially J1.

Then go around the outside of the container and mark wherever you want the openings to be for the off-board components - J1 and J2, SW1, R1, and D1. Again, the placement really isn't critical, except to keep them as close to the bottom of the container as possible and to make sure the components don't run into each other. For that reason, I thought it made the most sense to place them all 90 degrees from each other. I placed the LED right above the switch, and then placed the headphone jack to side of the switch that activates the headphone output. Next I have the input jack and finally the gain control. Once the spots are marked, drill a small starter hole for each one with a small bit (like a 1/16"). Your measurements will vary for your components, but for J1 and J2 the standard mounting hole diameters are 3/8" and 3/16". If in doubt, start smaller and round out the holes with a tapered reamer if you have one. This is a great tool not only for getting the holes just the right size, but keeping them round and smooth. Also works great for sheet metal panels and enclosures. If you have a snap-in grommet for the LED (I found one in my parts bin) those work well, or you could just push the top of the LED through the mounting hole and secure it with some glue from the inside. I found this 5mm LED grommet online at Radio Shack.

Once the holes are in place, pop each component through, add a washer to the outside and then thread on the mounting nut. Use some needlenose pliers to make sure the nut is on tight, since the surface of the container is curved slightly. I found a nice big knob to put on the gain control, there are plenty of places to find one if you don't have one in your workshop. In fact there are entire eBay stores dedicated to replacement and vintage guitar amp knobs, so have fun looking!

Next, place the circuit board in the container, positioned as far to one side as possible to leave room for the battery next to it and the speaker above it. I placed mine almost vertically, between the switch and the headphone jack. Next, drop in the battery. I found it fit best by laying it horizontally right in front of the circuit board. Depending on the depth of your speaker you may have to turn the battery to leave more clearance at the top. Finally, drop the speaker in on top, making sure to tuck the leads in underneath it. I found that with the Eclipse container, you can press down lightly on the edges of the speaker to get it to pop just under the rim at the top of the container. That makes threading the lid on a lot easier. If you use a different container (Dentyne for example), you may need to leave the speaker on top of the rim, and just thread the lid down as far as you can - just try to hold the speaker in place through the open lid so that it doesn't turn as you thread the lid on.

Congratulations - your sweet little portable guitar amp is completed and ready to start jamming!

Step 6: Final Thoughts

I'd love to see this project taken further - I've already found a few additional uses and have heard a few suggestions:

You can plug in any audio source you want (like an iPod) - you'll just need an adapter to convert your connector to a ¼" mono input plug.

You can certainly use other amplifier circuits - there are a lot of good "1 chip" audio amps out there, in Instructable and kit form. Or, pull some computer speakers apart and use the amplifier board from those.

Build a stereo amp and add another bottle/speaker.

Provide another audio input and a way to mix the signals for practicing guitar to an iPod or mp3 player.

Use the bottles as standalone speakers only, with another amplifier.

Make more interesting projects out of these gum bottle containers, they are pretty easy to work with. Why let the Altoids tins have all the fun?!

Check out these circular PCB's I just found at Radio Shack. Might make the circuit construction easier or fit better.

If you have an acoustic guitar without a pickup in it, try this Instructable - this is exactly how I added one to the guitar used in the video on the Intro page.

UPDATE: Headphones-only version (Rev 2.0):

A colleague of mine who is building one of these mentioned the need to lower the gain somewhat to make it more suitable for headphone use. I totally agree - for a guitar without its own volume control, the output can be too hot for comfortable headphone listening. I combined a few ideas into the schematic below and tested it out using a guitar with a simple piezo pickup (without a volume knob). It is much better for headphone practicing. Here are the main modifications:

New parts:
R3 - 18KΩ ¼-watt resistor
R4 - 100KΩ ¼-watt resistor
C4 - 10µF 16v capacitor

The gain control circuit consisting of C4 and R2 between pins 1 and 8 on the LM386 was removed. That original design allowed the gain to be adjusted from 20 to 200, but 20 was already too much for some guitars. Without those components, the chip defaults to a gain of 20. So in the new design, C4 and 18KΩ resistor R3 (a new component) were placed into the circuit between pins 1 and 5. This places some resistance in parallel with the chip's internal 15KΩ resistor, effectively lowering the gain from 20 to about 11.

The 10K pot R2 was pressed into duty elsewhere in the circuit to provide volume control at the input of

the amplifier. You'll also note the addition of 100KΩ resistor R4, which works with R2 as part of the input circuit. Note also that 10µF capacitor C5 was added between the chip's bypass pin 7 and ground to control some low-frequency feedback that was introduced by the other changes in the circuit. Finally, SW1 was replaced with a simple SPST (single-pole, singe-throw) switch to connect the battery to the circuit, since we don't need to switch between headphone and speaker output for this version of the amp.