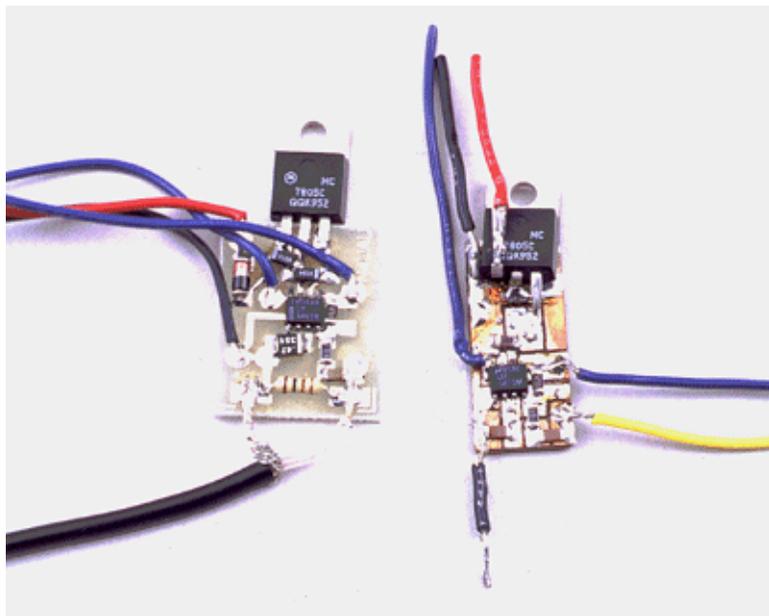


SMALL: A Surface-Mount Amplifier that's Little—and LOUD!

Build this project and experience working with surface-mount devices. You'll wind up with a high-quality audio amplifier that you can use for many applications.

By Sam Ulbing, N4UAU



About five years ago, I read a *QST* article written by Bryan Bergeron, NU1N, that described surface-mount technology (SMT) and urged amateurs to learn to work with surface-mount devices (SMDs). [1] During the intervening years, I noticed more and more SMT products listed in electronics catalogs, but didn't see any SMT projects that I could build. Then, about six months ago, I received a sample IC from National Semiconductor dubbed the "Boomer"—an audio-amplifier IC that's designed for use in boom boxes, etc. The IC's specifications are impressive and the circuit is simple. I noticed, however, that the chip is manufactured only in a surface-mount package. Clearly the time had come for me to bite the bullet! I'm pleased to say I find that SMT projects are definitely within the capability of the average radio amateur.

The Circuit

The schematic of **Figure 1** shows this amplifier needs few external parts. The signal is fed to the inverting input (pin 4) through C_i and R_i . The inverted amplifier output (pin 5) is fed back to the inverted input through feedback resistor R_F . The amplifier gain is set by the ratio of the two resistors: $\text{Gain} = 2 (R_F \div R_i)$.

I included R_L to provide a load for the input signal. It didn't seem to be absolutely necessary. I thought it might reduce distortion from the source, but it did not appear to have any effect.

Unlike amplifiers using the LM386 and similar ICs, no high-capacitance dc-blocking capacitor is needed at the output of this amplifier. That's because the LM4861 is *two* amplifiers in one. The first amplifier section inverts the signal; the second amplifier section inverts the inverted signal. Speaker audio output is derived from the output of these two amplifiers (pins 5 and 8). Both amplifiers have dc voltage at their outputs, but because each amplifier has the same dc voltage, the *net* dc voltage across the speaker is zero, so no dc-blocking capacitor is needed. This circuit arrangement is called a *bridge configuration* and it has another advantage. The ac signals of the two amplifiers are 180° out of phase, so the net ac voltage across the speaker is *twice* that of a single-ended circuit. Because power is related to the square of the voltage, *four times* as much power output is available. That's why the little chip is so loud!

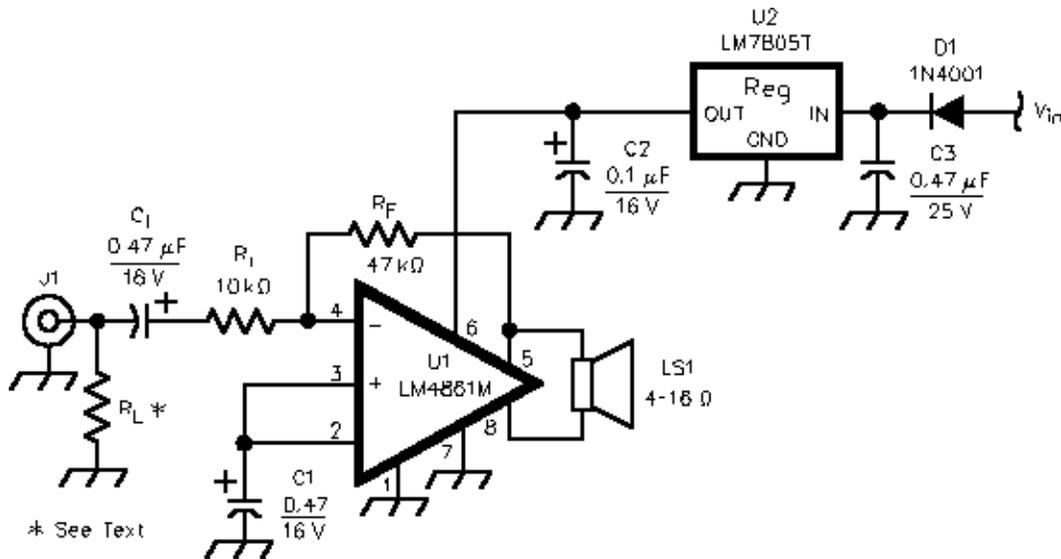


Figure 1—Schematic of the SMALL amplifier.

The Parts

The LM4861 small-outline (SO) package has eight pins spaced 0.050 inches apart: half the pin-spacing width of a standard LM386 DIP. The LM4861's package is well-suited for amateur use because the pins stick out the sides of the package (**Figure 2**) making it relatively easy to line up and solder the part to a PC board. The smallest components are the resistors—roughly 1/8 inch (0.125 inch) by 1/16 inch (0.063 inch). (My eyesight isn't the greatest, so I use an inexpensive, illuminated magnifying glass to see the parts clearly.) Rather than using color-code bands to show the resistor's value as "old-fashioned" resistors do, the ohmic value is printed on the surface-mount resistor package. The means of showing the value is similar to the system used on capacitors today. Thus, 103 is $10 \times 10^3 = 10 \text{ k}\Omega$. Surface-mount capacitors are physically only slightly larger than the resistors and often don't have their values printed on them. At first, I thought I'd purchased defective capacitors, but then recalled that the values are often printed not on the part itself, but *on the packaging strip* that they're supplied in. Polarized tantalum capacitors identify their positive terminals with a stripe and a notch in the metal contact on that side. See **Figure 2**.

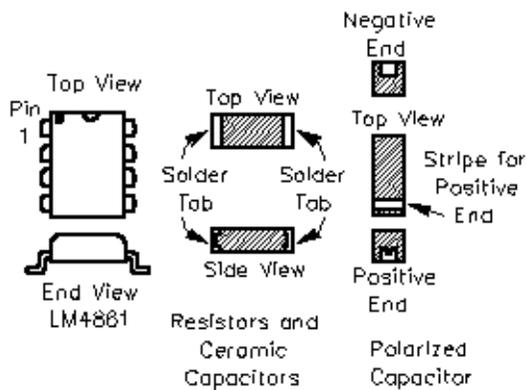


Figure 2—Packaging of some surface-mount components used in the project.

The PC Board

I know of no universal PC boards available for use with surface-mount devices. Prior to this project, I'd made only *one* circuit board in my life! I found the procedure to be messy and it was difficult to align and drill all the little holes required to mount the parts. I don't like to make PC boards, yet this project seemed so simple, I decided to try. Making the PC board turned out to be fairly easy—and there were no holes to drill! For those of you who don't want to make a board from scratch, a PC board and kit of parts are available. [2]

Building the Amplifier

Handling small surface-mount parts is obviously a challenge. Jameco sells a vacuum holder that they claim is good for this work (Vac Tweezer, #88268), but it costs \$30, so I passed it up. [3] I use a pair of tweezers (or my fingers) to hold the chip. Be careful though! If the part slips, it's apt to fly across the room. (I still have a resistor somewhere on the floor. Perhaps the vacuum cleaner will find it—I couldn't.) By pushing and prodding the part with tweezers and a small plastic tuning tool, I got it lined up.

Soldering the IC to the board was an adventure. The normal tip on my Weller WCC100 iron is too large. I found an ideal tip for it—Weller #ETJ—a 1/32-inch-wide chisel tip. Note that 1/32 inch is 0.030 inch, so it's small enough to put on one IC lead and not contact an adjacent lead. The chip is so small and light that whenever I touched the iron to it, it stuck to the iron and pulled away from the PC board! [4] The plastic tuning tool came to the rescue. I used it to hold the part to the board while I got two points soldered down. The legs of the IC need to sit flat on the board and they bend easily, so don't press down too hard.

I originally used standard 0.030-inch-diameter solder. This works fine for "old-fashioned" IC projects, but I found it too large for this project. One drop of this solder floods the pad and tries to flow over the cut between traces. The solder that does work is specially made for surface-mount devices. It's a silver solder, 0.022 inch diameter (Radio Shack #64-013).

Soldering the resistors and capacitors is similar to soldering the chip leads, except the resistors and capacitors don't have exposed leads. See **Figure 2**. I used two methods to solder them in place. For some, I tinned the PC-board pad and the part, then placed the part on the pads and heated the joint to remelt the solder. This works fine for the larger parts, but it's too hard to hold the smaller resistors and keep them from sticking to the soldering iron. So I put them on the board, held them in place with my tuning tool and soldered them.

If you mount a part incorrectly (as I did), you'll find it very difficult to remove. That's because the solder joint is both a mechanical and electrical connection. I normally use solder wick with great success. It does a fine job of removing excess solder, but enough solder remained between the board and the component to keep the component soldered to the board. When I used a knife blade to pry up the heated end enough to get it off the board, the opposite end often tore. Clearly, the best procedure is to heat both ends at the same time. There's a tool to do that, but until I get one, I guess I'll have to be more careful!

Designing an Amplifier with the LM4861

I wanted to use this amplifier for my 2-meter hand-held, which I frequently use in the car. With car noise, it's always necessary to hold the rig to my ear to hear anything. Now I can leave the H-T on the seat next to me and hear the audio with no problem. I plug the amplifier input into the speaker output of my Kenwood TH215A H-T and get plenty of sound. Because the hand-held is designed to drive a speaker directly, the amplifier's input voltage is fairly large. So, I selected an amplifier gain of 10 to allow full speaker volume while keeping the volume of the hand-held low to save its batteries and reduce distortion.

Out of curiosity, I plugged the amplifier into my Kenwood TM241A 2-meter rig's speaker jack. I didn't expect to realize any benefit from this because the rig's manufacturer claims an audio output of 2 W—more than twice the output specified for the LM4861. I was surprised to discover that the amplifier made a big improvement over an external stand-alone speaker. The audio is both louder and clearer. I think it's because the amplifier maintains its low distortion specs all the way up to maximum power output and across the entire audio spectrum.

The LM4861 is designed to operate from supplies of 2.7 to 5.5 V (the absolute maximum is 6 V). This makes it ideal for battery power. Four rechargeable cells deliver about 5.6 V when fully charged and can be connected directly to the circuit. If you use alkaline cells, four new ones would deliver 6.4 V, which exceeds the absolute maximum of 6 V, so you need a diode in series with the supply lead to keep the power to the chip at less than 6 V. You can, of course, use only two or three cells, but because the resulting supply voltage is lower than ideal, you'll not get as much power out of the amplifier.

I use a 5-V regulator for my mobile amplifier and power it from the car's 12-V system. This amplifier delivers over 1 W peak output. Assuming 50% efficiency, that's an input of 2 W. At 5 V, that power level requires a peak current of around 400 mA. You'll need a regulator in a TO-220 case. For mobile use—with battery voltage of 14.5 V and an output of 5 V—the regulator needs to dissipate up to 4 W. Although a heat sink isn't mandatory, it's a wise precaution.

If you want the best sound and maximum power from this little amplifier, you'll need a speaker that can handle a fair amount of power. Two-inch speakers rated at 0.5 W will quickly distort the audio. I found a compact 5-W speaker that works well. [5]

The bridge circuit has many advantages, but does limit you to a floating output. If your speaker must have one end grounded, you can still use the LM4861, but you'll need to modify the circuit and add an output coupling capacitor. Take the output from pin 5 through a 470- μ F capacitor. Connect a 0.1- μ F capacitor and 2-k Ω resistor in series between pin 8 and ground. Of course, the power output of such an arrangement will be one-fourth that of the arrangement shown here. See the National Semiconductor data sheet for more information.

Summary

You'll be surprised at the number of places this little amplifier comes in handy. It can be used as a portable amplifier with an appropriate battery supply. In the shack, it can often improve the sound of your favorite rig's audio. If you have a QRP rig that requires headphones to hear the audio, you can use the amplifier to drive a speaker. The amplifier's small size allows you to build the amplifier into most speaker enclosures.

You can contact Sam Ulbing at 5200 NW 43rd St, Suite 102-177, Gainesville, FL 32606; e-mail: n4uau@afn.org. Sam has a BEE (1964) and an MBA from Cornell University. Most of his work experience was in the financial area. When he retired in 1986, Sam was amazed to discover the changes that had taken place in the electronics field. Returning to his original interest in electronics, Sam got his Novice ticket in 1988, and because of his interest in CW and building electronics projects, was able to quickly upgrade to Extra class. Sam feels that the new electronics products with complete systems on a single IC offer many opportunities for the amateur builder. Sam's shared a number of his circuits with the readers of QST, QEX and The ARRL Handbook.

Notes

¹Bryan Bergeron, NU1N, "A Surface-Mount Technology Primer—Part 1, QST, Dec 1990, pp 48-51; Part 2, QST, Jan 1991, pp 27-30.

²Surface-mount devices are available from larger parts distributors, although they often sell SMT resistors and capacitors only in large quantities. I can provide a kit of the parts to build this amplifier for \$12.75. The kit includes the PC board and all board-mounted parts shown in **Figure 1**. Add \$1 for shipping; Florida residents please add sales tax.

³Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002, tel 415-592-8097, fax 415-592-2503 and 415-595-2664.

⁴See the 1996 edition of *The ARRL Handbook*, pages 25.11 to 25.12 for information on SMT soldering techniques.

⁵Hosfelt Electronics #13-346, Hosfelt Electronics, 2700 Sunset Blvd, Steubenville, OH 43952, tel 800-524-6464; 614-264-6464; fax 614-264-5414.