

The Secret Art of Breadboarding

You can test a circuit idea with one of these quick 'n' dirty breadboarding approaches.

I have an audio power amplifier circuit that is simplicity itself. It uses ten bipolar transistors, two MOSFETs, and an op amp. My simulation program shows it has less than .001% distortion and can deliver 1000W into an 8Ω load.

BACK TO BASICS

Unfortunately, common sense told me it would not work, but just to be sure I built a trial version. It oscillated, was noisy, overheated, and was completely useless. That is why before I design and order a printed circuit (PC) board, I find it useful to test out the circuit. Sometimes, when I build a one-off for my own use, it never sees a PC board.

There are many ways to build a trial circuit. You could start with a piece of wood, drive small brass tacks into it, and use these for solder terminals. To be completely accurate, you could use a real breadboard!

If you want to try this method, you might build a crystal radio. You will need a cardboard tube, some magnet wire, a wire coat hanger, a 1N34 germanium diode, a crystal earphone, perhaps four Fahnestock clips, a few nails, brads, or tacks, and a piece of wood. The larger the diameter of the cardboard tube, the better. You can use the center of a roll of bathroom tissue or an oatmeal container (Photo 1).

I used a piece of 3" mailing tube, which was very

rigid, making winding the coil easier. I put a small hole in each end of the tube to hold the wire and I wound as much of the surface of the tube as I could with a single smooth layer of 22-gauge wire (you can also use thinner or thicker wire). It is important to be sure the wire does not overlap a previous winding. You can use a spot of glue to hold the wire. I used almost 6 ounces of wire to cover my tube.

You can coat the entire coil with polyurethane to hold it in place while sanding it. Some folks might just use varnish or shellac, but shellac—although traditional—doesn't really hold well enough. If your coil is wound really tightly you

might skip this step.

Using 220-grit sandpaper, I then sanded the insulation off a band across the top of the coil to allow for the tuner rod to have good contact. If you accidentally wind one wire over another, then you might just sand through it. Be careful.

Nail your tuning coil to your board. Arrange a piece of coat hanger that has also been sanded clean to act as a tuning lever. Use your Fahnestock clips for the antenna and earphone.

This is a classic school science fair project, or, if you make it look old, something of a collectable reproduction. But it really is a simple way to breadboard a circuit.

SWEEP GENERATOR

For those who want something fancier, the next step up is a small metal plate, which can be a piece of printed circuit stock or thin brass or copper "shim stock." You can buy brass shim stock at many hobby outlets. I used to use the stock 0.032" thick, but as prices have risen, I tend to use more of the 0.020" material.

The reason for using copper or brass is so that you can solder directly to it. It provides a very good ground plane. The parts that are grounded are also used as standoffs for the other parts. Air makes a great insulator for the other parts. If you need an extra support, you can add an extra power sup-

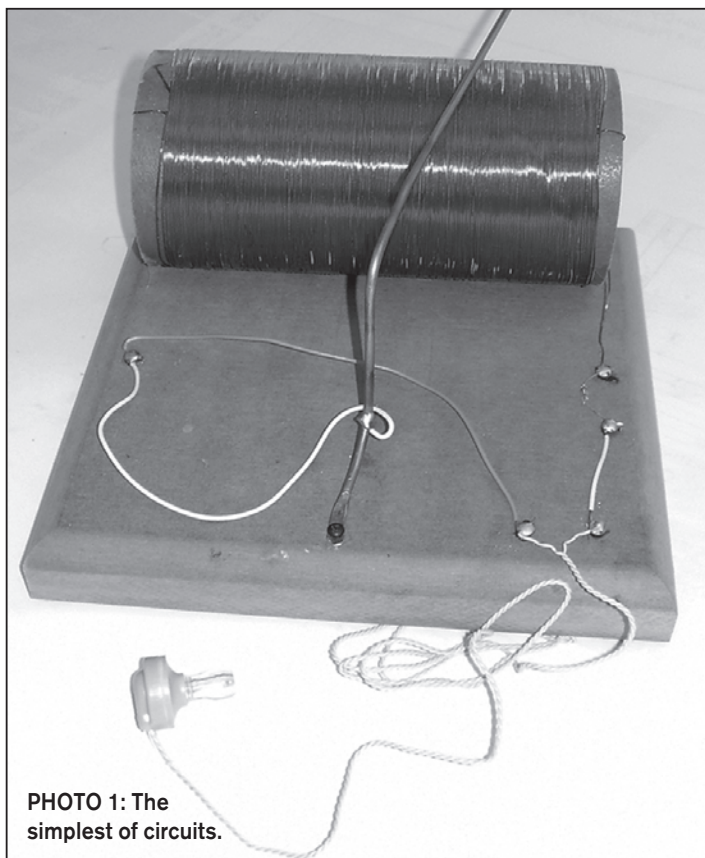


PHOTO 1: The simplest of circuits.

ply bypass capacitor or even a very high value resistor. Sometimes you can make a complete box out of brass and use it for both chassis and case.

Photo 2 shows an RF sweep generator I built using two voltage regulators, a simple saw tooth generator, and a voltage-controlled oscillator module. It puts out an RF signal from 80MHz to about 120MHz and is used for sweeping the FM band. Outputs are provided to connect to an oscilloscope to display the frequency response of a tuner's front end. On one connector is the diode detector to get the DC level for the display.

You can see how lots of bypass capacitors are used as standoffs. This is not particularly neat, but is quite practical for these frequencies and ease of modification. Because I needed only one for a few uses, this is the final product. The front panel has RF out and RF return. The back panel has horizontal, vertical, and common to the display.

A variant of this technique is to use the circuit board material and cut insulated areas with a razor knife or engraver. This gets you closer to a PC board type of product.

SIMPLE CIRCUIT

A slightly fancier method is to use perfboard, which is available from most electronics suppliers. The most common type used today has small 0.042" holes on a 0.100" matrix. You can use push-in "flea" clips to hold components or just wire them through the holes.

Photo 3 is a simple circuit for using white LEDs as a light source. Note that the current limiter is a capacitor and this circuit is fed by AC through a diode bridge. This method gives a physically more secure product than the metal-based breadboard.

Many people prefer to use a universal circuit board to hold the trial circuit. There are lots of different types of these boards available—from the catalogs at Digi-Key, Mouser, or Old Colony. When I am having circuit boards made, there is often extra space on the panels that I do not need for the project at hand, so I add a few extra IC patterns and traces to give me a few prototype boards.

OSCILLATOR

Photo 4 shows a 100kHz calibration

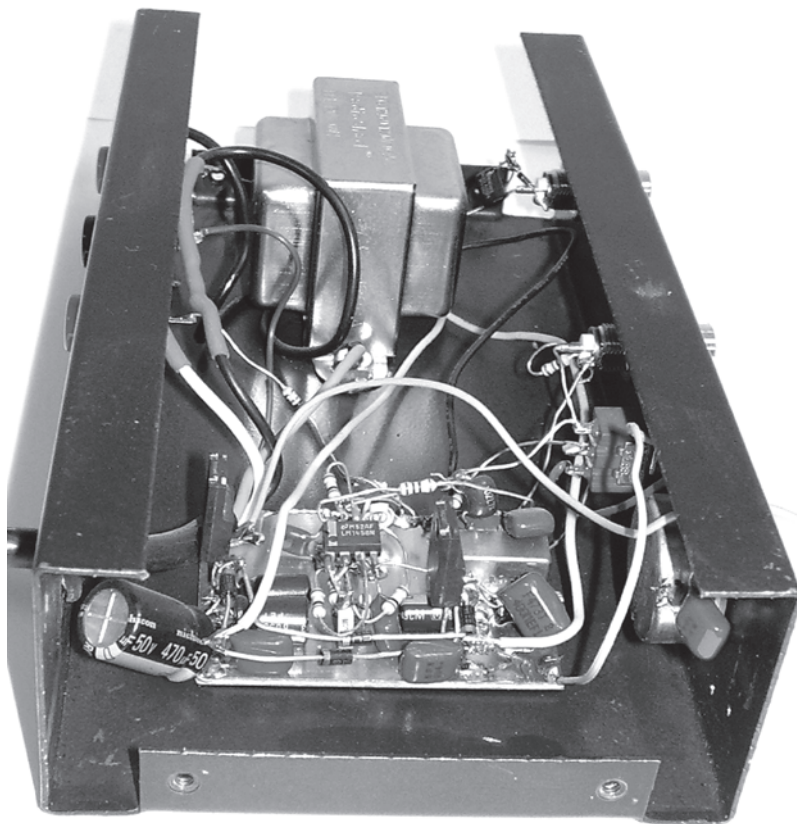
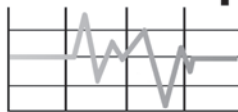


PHOTO 2: RF sweep generator.

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oscillator I needed to calibrate an old oscilloscope. The 9V battery snap was removed from a dead battery and re-used. The basic circuit is a multi-vibrator with the crystal in the feedback loop. Although you could trim such a circuit to WWV with a receiver, in this case such accuracy was not needed. The universal card was from Radio Shack.

Short lead lengths are very important in a circuit such as this, so this is not particularly neat. When I was in a college lab class, Tron always insisted that his wiring be perfectly neat and square. With his complete routing list and by doublechecking each wire as he installed

it, it took him longer to build his circuits than anyone else. He insisted that they always work the first time. The teaching assistant who had to stay for two extra hours after the two-and-a-half hour lab session was not very pleased when it did not work!

A test circuit is just that. Do what it takes to test your ideas. It needs to be neat enough to allow for modifications, but if it is not a keeper, you may wish to invest your time in something more productive.

So far these breadboards have been for simple circuits. A method that I use is to take a punched metal plate and

mount terminal strips on it. The plate can hold heavy components and the terminal strips the lighter ones. If you do a neat job, the finished plate can stand alone or be mounted in a wood case. The plate shown just has four rubber feet stuck onto the bottom.

Photo 5 shows a prototype power amplifier. This layout is very easy to modify for both topography of the circuit and change components to see what effect different values have on the per-

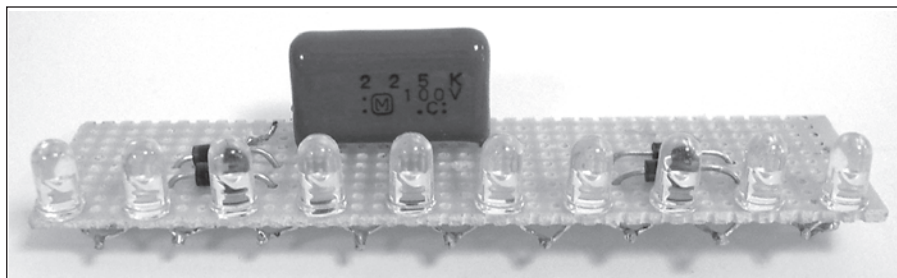


PHOTO 3: Simple circuit.

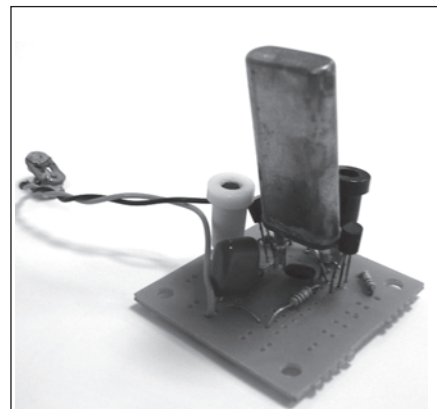


PHOTO 4: 100kHz calibration oscillator.

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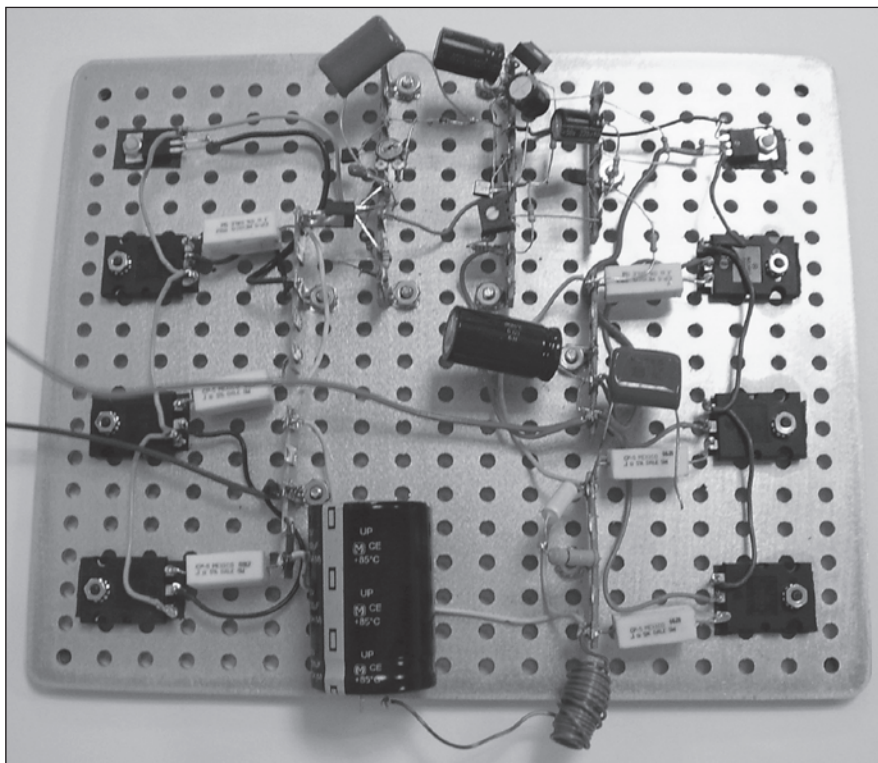


PHOTO 5: Prototype power amplifier.

formance. The transistors are mounted directly on the plate, which also doubles as a bit of a heatsink. The terminal strips are available from Mouser.

The hole spacing is a bit tricky. One axis is $\frac{1}{2}$ " spacing, the other is 1cm. I can install both English and metric components on the plate. If you are building for show, you should be sure all the components are anchored at both ends on a terminal. Wire can then run between the terminals to make the connections. You can order metal parts such as these custom made or from folks such as Design, Build Listen.

Of course, another breadboard method is to start with a circuit board that is similar to what you want to end up with. You can then build the extra circuits in the air above and use the existing pads as tie-ins and supports. You can split traces with a sharp knife to add or change the circuitry. Sometimes you can take an existing card and add a small breadboard to it for just the experimental circuitry.

Many people will design a circuit, test it with simulation, and then lay it out as a PC board. I have found that simulation is just that. It is not the actual operation, and there are usually small differences—and sometimes gigantic ones—that exist in the real world. That

is why I like a quick test bed. Even with whiz-bang computer programs, the best simulator is still a soldering iron. *aX*



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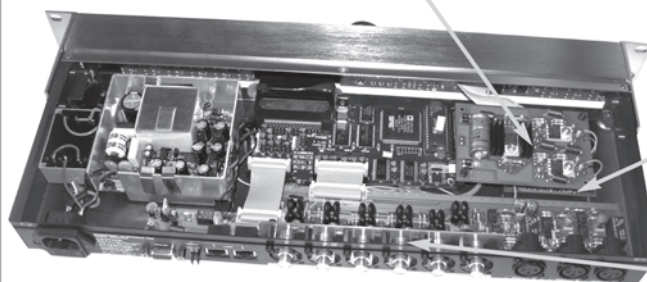
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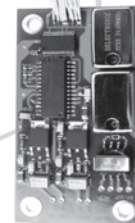
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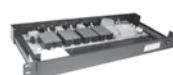
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