EASY PITCH CONTROL HACK

Make audio circuits sing higher and lower.

By Peter Edwards

Here's an easy way to add a pitch adjustment to audio circuits such as the ones in many kids' toys, in order to greatly enhance their circuit-bending potential.

All you have to do is replace the circuit's fixed clock-speed resistor with a variable resistor (aka potentiometer) and a limiting resistor, wired in series (Figure A).

Then, simply turning a knob will dial the circuit's base pitch up or down, which not only raises and lowers the sounds it generates, but can also unlock bizarre hidden behaviors.

Overclocking the pitch of some audio circuits makes them malfunction and spit out random sounds and melodies. And setting the pitch very low can reveal micro-modulated tones that are otherwise impossible to hear. Fun!

Photography and diagrams by Peter Edwards

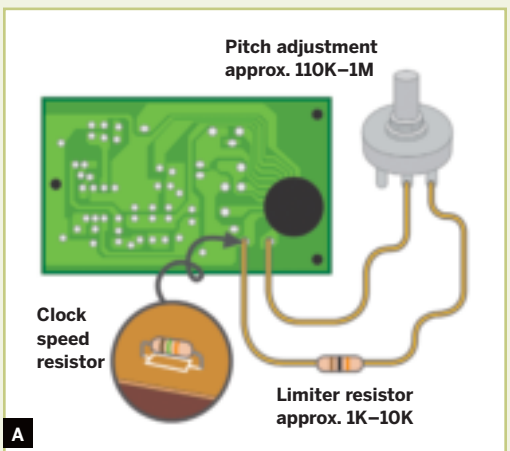


Fig. A: Replace the clock speed (aka pitch) resistor with a potentiometer and a limiting resistor.

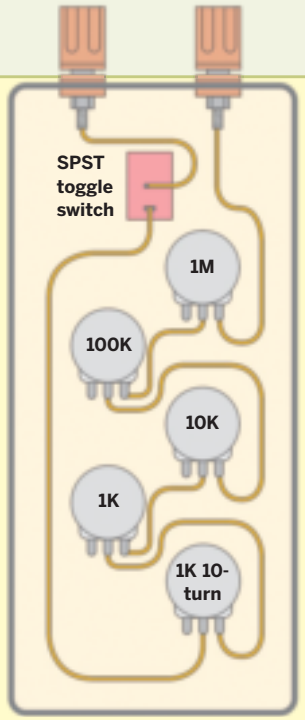
Resistor Substitution Box

For finding ideal potentiometer and limiting resistor values, I use a resistor substitution box. You can buy these, but I built one myself in about an hour. It has 5 pots wired in series: 1kΩ, 10kΩ, 100kΩ, 1MΩ, and a fancy 10-turn 1kΩ pot with a 3-digit dial that I liberated from some old test equipment (substitution: Mouser part #882-DC22-10-1K, $75).

Connecting the box into a circuit and adjusting its knobs from top to bottom lets you zero in on the value that works best for any set resistor. Then you simply read the resistance off the box using an ohmmeter. A toggle lets you switch over from infinite resistance.

I use my resistor substitution box a lot, to dial in resistor values that determine pitch, brightness, motor speed, and other circuit characteristics.

CAUTION: Unless you're a trained electrical engineer, you should only work on circuits that are battery powered, or that use a very low-amperage power supply (50mA or so). Poking around inside high-voltage and/or high-current circuits can be fatal.



MATERIALS

- **Digital audio circuit, battery-powered and fairly simple** Kids' toys are fair game; they're cheap and easy to find, and they usually make lots of different sounds. For this article I used a Multi Voice Changer megaphone sold under the Toysmith and Tech-Gear brands.
- **Potentiometers** The value of the pot used will vary from project to project, so it's good to have an array on hand: 1kΩ, 10kΩ, 100kΩ and 1MΩ.
- **Resistors** The value used will vary between 1kΩ and 10kΩ. I suggest buying in bulk from mouser.com, or getting a sampler pack from radioshack.com or jameco.com.
- **Knobs** to fit potentiometers
- **Insulated wire, around 22-gauge**
- **Heat-shrink tubing, ⅛" or ¼" diameter**

TOOLS

- **Soldering iron and solder**
- **Wire cutters and strippers**
- **Screwdriver** to disassemble toy or other circuit source
- **Multimeter or ohmmeter**
- **Alligator clip leads (4)**
- **Drill and drill bits** for mounting the potentiometer in the housing
- **Resistor substitution box (optional)**

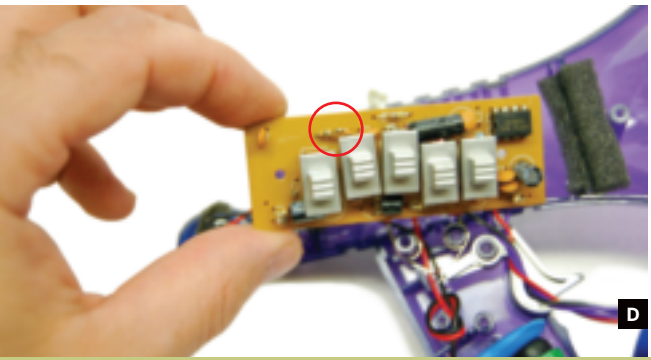
Audio Circuit Clock Speed

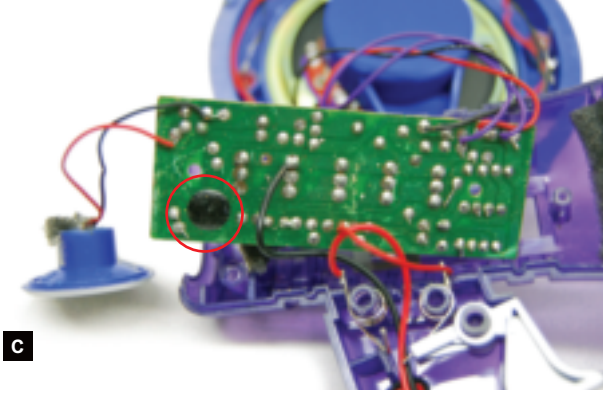
All digital audio electronics rely on a clock, which determines the rate at which the circuit produces and processes data. With circuits that generate audio, the clock speed typically determines a base pitch that all outputs then derive from.

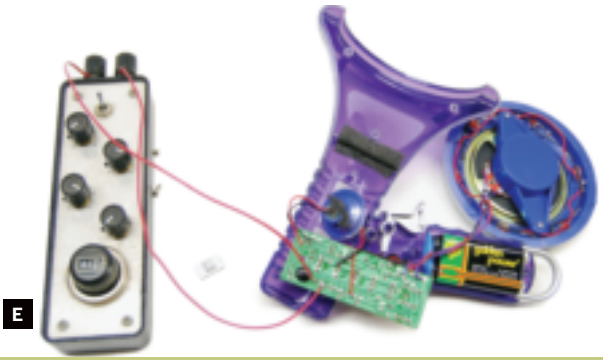
With most cheap audio circuits, this clock speed is set by the value of a resistor sitting between the circuit's power supply and the main chip's clock speed node, or sometimes between 2 clock speed nodes on the chip. This is the clock speed resistor, aka pitch resistor, and the quick hack described here works for circuits like this.

Other audio circuits set their clock speed using a crystal or inductors, so adding a pitch control to them requires more involved circuitry. You'll start this project by determining whether or not your circuit has a clock speed resistor. If you follow the steps below and still can't find it, you probably have one of these other guys, and you should find a different circuit to modify.

NOTE: This project is the simplest way to add a pitch adjustment to audio circuits that have a pitch resistor. More complicated methods allow for a wider pitch range and finer tuning.







Figs. B and C: Search the circuit board for the audio generation IC, which is often a black blob "gumdrop." Fig. D: The pitch resistor is usually the resistor closest to the audio generation IC, often on the back.

Fig. E: Replace the pitch resistor with a potentiometer of a greater value. A resistor substitution box makes the process a lot easier.

1. Find the pitch resistor.

First, open the device you intend to hack. Make sure you put all the screws in a safe place! Examine the circuit board and try to find the audio generator or "brain" of the circuit. This is usually a black blob covering a proprietary chip; these are also called "gumdrop" ICs. With my Voice Changer toy, this was on the green, solder-pad side of the board rather than the yellow, component side (Figures B and C).

If your circuit has no gumdrop, the biggest chip is likely to be where the audio signal is generated. (If your circuit has no chips at all, you're probably dealing with an analog circuit. This is a different beast altogether, and it requires different steps to modify than the ones outlined here.)

Once you've found the brain, look for the closest resistor, which is usually on the reverse side of the board (Figure D), because 9 times out of 10 this will be your pitch resistor. Test your theory by touching the resistor's leads while the circuit is making sound. If you're right, the pitch should jump up or down.

If you hear no change, lick the tip of your index finger and touch other parts of the board to see if they affect the pitch. When you find a spot, narrow down your search (start using your pinky) until you've found a single point or two at a resistor that alter the pitch. If you still can't find this, your circuit may not be using a resistor to set the clock speed.

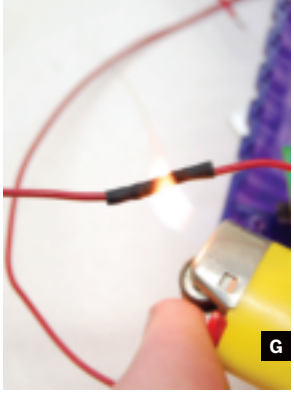
2. Swap in a potentiometer.

Once you've found the clock speed resistor, make a note of its value by reading the stripes. Turn the circuit off or remove its batteries. Unsolder the resistor and remove it from the board, then solder 2 wires about 8" long to the same contacts. These wires will attach to a potentiometer.

To find the best value of potentiometer to install, I use one of 2 different methods. The quick and dirty method is to just multiply the value of the original pitch resistor by 10 and try a pot that's roughly the same value. If the original value is 15kΩ, for example, replace it with a 100kΩ potentiometer.

Clip the pot to the leads with alligator clips, one to the middle wiper leg and the other to either of the fixed contacts. Then power up the circuit and see how the pot performs. You may need to try a few values before you find the right one.

WARNING: Don't turn the potentiometer all the way up at any point during your testing. Turning the pot to zero resistance can fry your circuit.



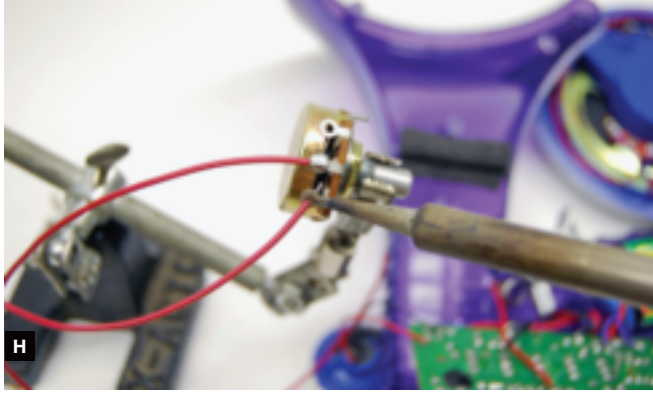


Fig. F: Wire up a limiting resistor to keep the pitch from going too high. Fig. G: Shrink a 1" piece of heat-shrink tubing over the resistor. Fig. H: Wire up your potentiometer.

Fig. I: Another toy with a pitch control pot wired in. Fig. J: Mount the potentiometer in the housing and put it all back together.

A better method for finding a proper potentiometer is to connect in a resistor substitution box (see sidebar on page 128). Twiddle the knobs to find a resistance range that affects the pitch nicely (Figure E, previous page), then measure the resistance across the box and round it up to your nearest potentiometer value.

3. Install a peak-limiting resistor.

To limit the peak pitch and avoid damaging your circuit, you also need to add a limiting resistor. Clip your chosen potentiometer into the circuit, then carefully turn it up until the pitch is as high as you want it to go. Glitching is fine, and part of the fun. You'll be safe so long as the output stays within a pleasant and musical range — but if you go too far, you'll get a one-way ticket to burnt-out-circuit-land.

Use an ohmmeter to determine the potentiometer's resistance when it's turned as far as you dare, and find a resistor that's about the same value. This will usually be between 1kΩ and 10kΩ. If you don't have an ohmmeter, I suggest starting with a 1kΩ resistor. It may need to be increased some, but it will work in many cases.

Solder the resistor to one of the leads from the board (Figure F) and insulate the connection with heat-shrink tubing (Figure G). Then solder and insulate a short lead to the other side of the resistor.

4. Mount the pot and close up the housing.

Solder the potentiometer to the free leads from the board and the limiting resistor (Figures H and I). Then choose a location for your pitch adjustment knob, making sure there's room inside for the back of the pot. For my Multi Voice Changer, I picked a prominent spot on one side of the megaphone's bell (Figure J).

Drill a hole for mounting the potentiometer, and add the knob on the outside. Once that's done, carefully replace the circuit board and close up the housing. Done!

+ Visit makezine.com/23/diymusic_pitch for links to more information on this technique, as well as methods for adjusting crystal set pitch.

Peter Edwards is a circuit-bending and creative electronics pioneer based in Troy, N.Y. He builds electronic musical instruments for a living through his business, Casper Electronics (casperelectronics.com).