



## SpikerBox v1.3 DIY Instructions

Prepare yourself. In 2-6 hours, you will have built your own SpikerBox to begin doing neuroscience and whatever your creative mind can conjure.

### Materials Needed:

1. A Backyard Brains Bag of Parts
2. Soldering Iron
3. Solder
4. Magnifying Glass to read labels on Chips and Capacitors
5. 9V battery to power your SpikerBox.
6. Silly Putty to hold components in place on board while you solder on backside
7. Pair of scissors
8. Wire Strippers and Wire Clippers
9. Superglue (gel is best) to glue speaker into enclosure.
10. Electrical Tape

*A Soldering Iron can be purchased at RadioShack or any local hardware store. The Magnifying Glass and Silly Putty are available at drug stores.*

### SpikerBox Circuit Construction (refer to photograph on next page while building):

1. Solder Speaker Connector
2. Install Audio Line Out
3. Install Power Switch
4. Install LED (bulb pointing out)
5. Install RCA signal in
6. Install Chip Holders. The half circle should point toward the front of the board (where input, switch, LED, and line out are).
7. Install 220 uF capacitor (big one) at C3. Grey Stripe needs to point toward connector row (see photo).
8. Install 10 uF (blue cap) capacitor at C10, C1, and C2. These have "106" labels in small text on them
9. Install 10 kΩ resistors at R1 and R2 (brown black orange).
10. Install 390 Ω resistor at R5 (near LED) (orange white brown)
11. Install 33 kΩ resistor at R6 (near RCA signal in) (orange orange orange)
12. Install 1 kΩ resistor at R7 (brown black red) and
13. Install 0.47 uF capacitor at C7. The capacitor has "474" in small text on it.
14. Install 220 kΩ resistor at R8 (red red yellow).
15. Install 560 pF capacitor at C8. The capacitor has "561" in small text on it.
16. Install 0.047 uF capacitor at C4. The capacitor has "473" in small text on it.
17. Install 10 Ω resistor at R3 (brown black black).
18. Install 0.1 uF capacitor at C5. The capacitor has "104" in small text on it.
19. Install the 9V battery connectors. Take care to ensure the two connectors are flush with each other or else battery will not plug in. The "skinny" connector (male) goes on the bottom of the board. We recommend soldering with a battery in place.
21. Install Chips in holders, with circle on all chips pointing towards top of board. AD623 goes in left holder, LM386 on right holder, and the TLC2272 goes in the middle holder.
22. Install battery.

### Enclosure Construction:

1. Remove paper backing from the SpikerBox plastic enclosure pieces (or you can leave these on)
2. Place screws in bottom plastic enclosure piece, with screws facing up.
3. Measure your tubing and cut it into 4 equal parts of 0.75 inches and 4 parts of 0.25 inches.
4. Place 0.25 inch spacers on top of screws.
5. Slide your circuit board through the screws on top of the 0.25 inch spacers, and then put the 0.75 inch spacers on top of the circuit board through the screws.
6. Solder Speaker Connector (female) on ends of speaker wire. Take care that the two solder joints do not touch. Separate and wrap solder joints away from each other using electrical tape
7. Press the speaker into the enclosure, then attach the female end of the cord to the male end of the PCB. If the speaker doesn't fit, you can lightly sand the inner hole until the speaker fits. You can use just a touch of superglue in the inside hole to secure speaker. Be careful—superglue smears acrylic very easily.
8. Slide the top enclosure board on your circuit, , and add the hex nuts to the top of the SpikerBox. Note that the nuts could go either on the top or bottom of the board. There is an internal struggle here at Backyard Brains on which looks better: Nuts up vs. Nuts down. It's your SpikerBox, you decide.
9. Peel and place the cork sticker to the right of the speaker, close to the RCA jack.

### Electrode Construction:

1. Unscrew end of RCA connector.
2. Split and Strip  $\frac{1}{2}$  inch lengths from speaker wire on both sides and both ends.
3. Place wire in eyelets of RCA connector, solder, and crimp where applicable. Take care that connections are both strong and not touching each other.
4. Rescrew RCA end back on connector.
5. Solder two sewing needles on other ends of speaker wire.

Congratulations! You are done. Turn on your SpikerBox. If your LED comes on and you hear your speaker "Click on", your SpikerBox probably works. Now grab your favorite invertebrate and do some experiments.

### What resistor is what?

Resistors have 3 color stripe bands that signify their values. For example, a 10 Ohm resistor is Brown, Black, Black as below:

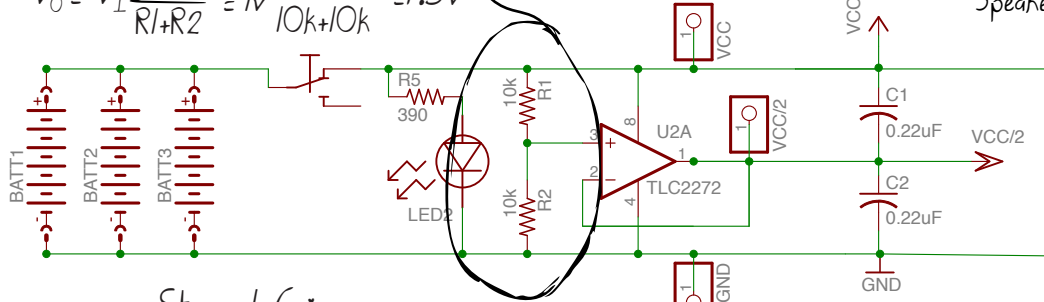


Sometimes you will find an extra silver or gold stripe, but you can ignore those. (They specify the tolerances, 5%, 10%, etc). For your kit, you will need the following values:

- 10  $\Omega$  = Brown Black Black
- 390  $\Omega$  = Orange White Brown
- 1 k $\Omega$  = Brown Black Red
- 10 k $\Omega$  = Brown Black Orange
- 33 k $\Omega$  = Orange Orange Orange
- 220 k $\Omega$  = Red Red Yellow

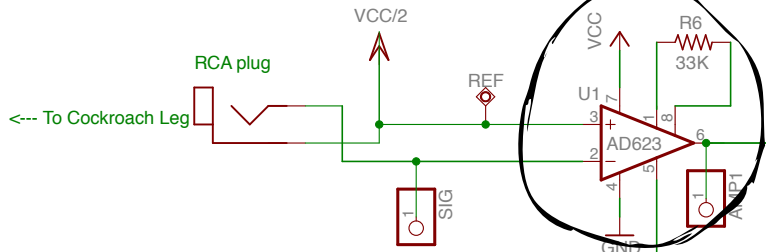
This turns 9V into +/- 4.5v

$$v_o = v_i \frac{R_2}{R_1 + R_2} = 9v \frac{10k}{10k + 10k} = 4.5v$$



Stage 1 Gain

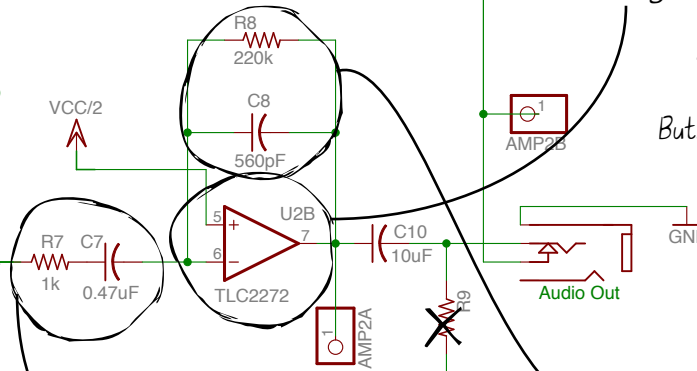
$$\text{gain} = 1 + \frac{100k\Omega}{33k\Omega} = 4.03x$$



High-Pass filter

$$f_c = \frac{1}{2\pi \cdot R_7 \cdot C_7} = 338 \text{ Hz}$$

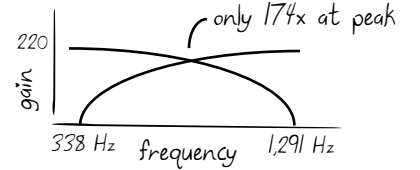
174x Band-Pass Filter Stage



Stage 2 Gain Calculation

$$\text{gain} = R_8 / R_7 = 220k / 1k = 220x$$

But... In reality it's lower due to roll off:

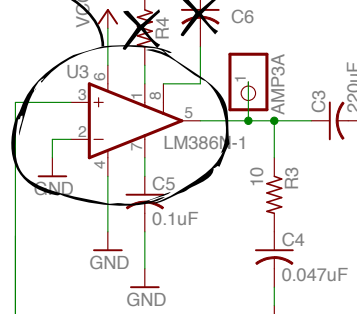


Low-pass Filter

$$f_c = \frac{1}{2\pi \cdot R_9 \cdot C_4} = 1,291 \text{ Hz}$$

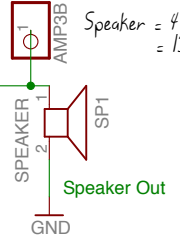
Stage 3 Gain  
Speaker Amp default  
20x

20x Gain Audio Amplifier



Total Gain

$$\begin{aligned} \text{Headphone Out} &= 4x \cdot 174x \\ &= 696x \\ \text{Speaker} &= 4x \cdot 174x \cdot 20 \\ &= 13,920x \end{aligned}$$



## Backyard Brains

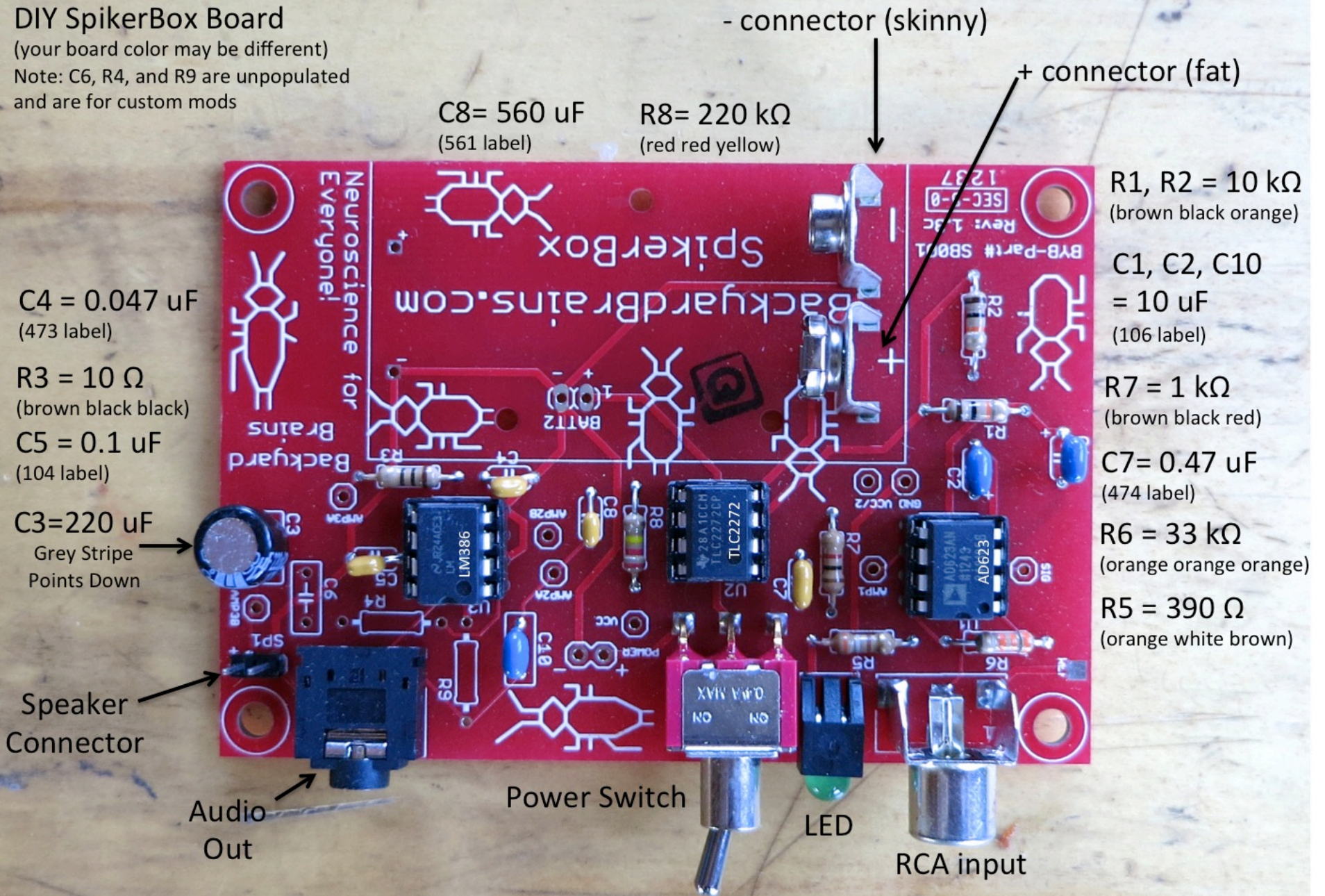
SpikerBox v. 1.3c  
Dec 22, 2011

open source hardware

# DIY SpikerBox Board

(your board color may be different)

Note: C6, R4, and R9 are unpopulated and are for custom mods



- connector (skinny)

+ connector (fat)

C8= 560 uF  
(561 label)

R8= 220 kΩ  
(red red yellow)

R1, R2 = 10 kΩ  
(brown black orange)

C1, C2, C10  
= 10 uF  
(106 label)

R7 = 1 kΩ  
(brown black red)

C7= 0.47 uF  
(474 label)

R6 = 33 kΩ  
(orange orange orange)

R5 = 390 Ω  
(orange white brown)

C4 = 0.047 uF  
(473 label)

R3 = 10 Ω  
(brown black black)

C5 = 0.1 uF  
(104 label)

C3=220 uF  
Grey Stripe  
Points Down

Speaker  
Connector

Audio  
Out

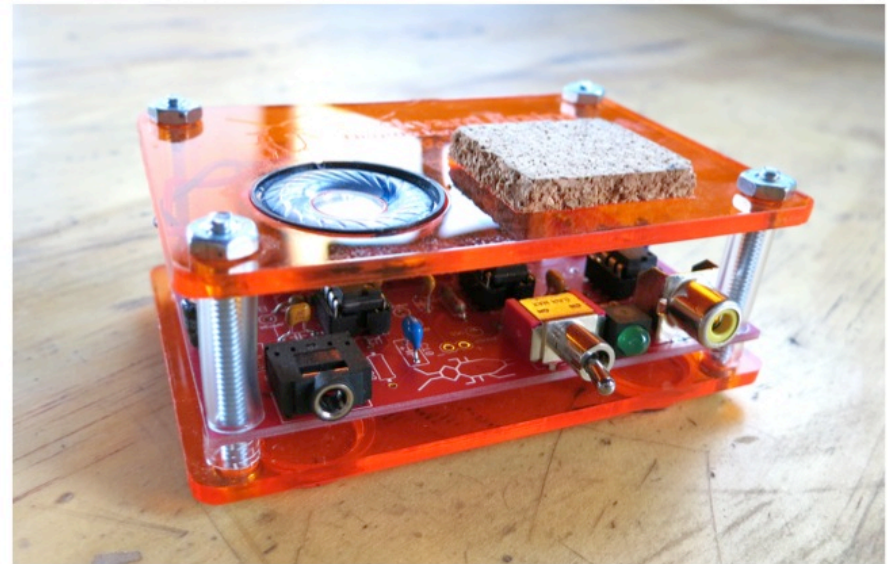
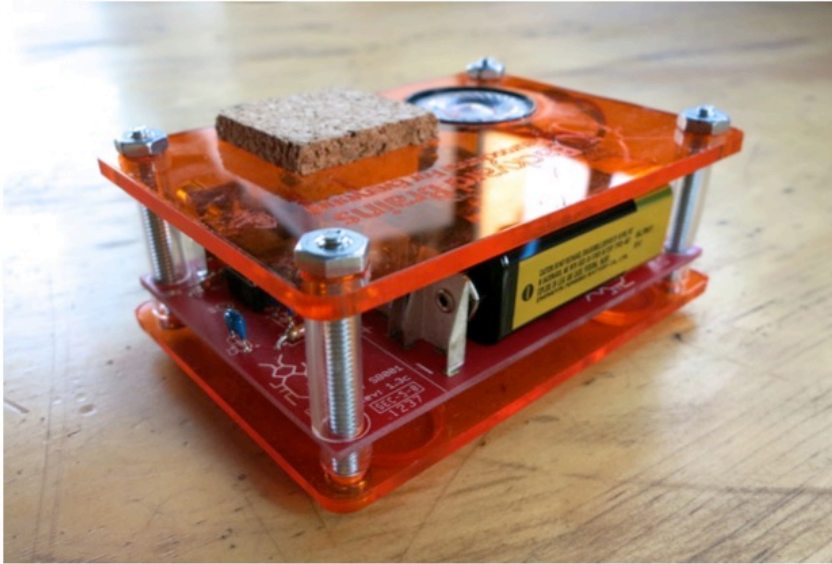
Power Switch

LED

RCA input

Make sure all chips face towards the connectors (notice circle or half-circle mark in corner of chip)

## What your Completed SpikerBox Looks Like



## With Electrode Attached

