SparkPunk Hook Up

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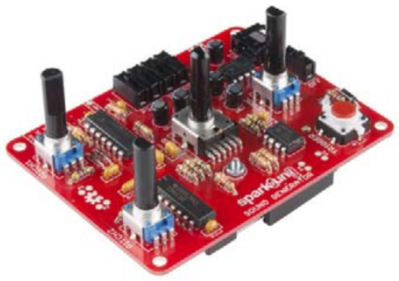
Lesson Overview

In this lesson students explore how a simple synthesizer (electronic machine that produces sound) works by assembling, testing and modify the SparkPunk (a simple synthesizer by Sparkfun). Students will explore various electronic components (integrated circuits, potentiometers, switches, diodes, resistors and capacitors) and their function within this application.



The SparkPunk, fully assembled

Lesson Synopsis

Introduce students to:

- A simple synthesizer
- Assembling, testing and modifying a synthesizer
- Integrated circuits, potentiometers, switches, diodes, resisters and capacitors

Target Age Levels

Ages 13-18

Objectives

Students will understand:

- How a simple synthesizer works
- Various electronic components and their functions
- Assembly (soldering) and testing of electronic components

Anticipated Learner Outcomes

As a result of this activity, students will be able to:

- Assemble, test, and modify a synthesizer

Lesson Activities

Student explore various electronic components, assemble by soldering components to the printed circuit board (PCB), test, and modify the synthesizer.

Materials Needed

For each student or student team:

- SparkPunk Hook Up Kit by DigiKey (#11177)
- SparkPunk Hook Up Guide

- Soldering Iron **(Students will need to solder**)**
- Lead-based or Lead-free solder
- Diagonal or Flush cutters
- Small Philips Screwdriver
- Headphones or a small speaker to test the output once the kit is complete.
- Additional Tools and Supplies
    - Safety Glasses
    - Magnifying glass or Loupe
    - PCB Vise or Third Hand
- Student Resource Sheets
- Student Worksheets

Resources

- How a synthesizer works: https://www.explainthatstuff.com/synthesizers.html
- Integrated Circuits by Kiddle: https://kids.kiddle.co/Integrated_circuit
- **How to Solder Through Hole Video by SparkFun: https://sparkfuneducation.com/how-to/how-to-solder-through-hole-soldering.html
- **How to Solder Comic Video by SparkFun: https://sparkfuneducation.com/classroom-downloads/how-to-solder.html
- **How to Solder by ScienceBuddies: https://www.sciencebuddies.org/science-fair-projects/references/how-to-solder
- **Soldering Beginners Guide By Makerspaces.com: https://www.makerspaces.com/how-to-solder/

Optional Writing Activity

- Write an essay (or paragraph depending on age) answering:
  How has the invention of the integrated circuit impacted society? Or
  How has the invention of the synthesizer had an impact on the music industry?

For Teachers:
Teacher Resource

Part 1: *Electronic Assembly* ***Diodes***

- **Lesson Objectives**
  Students will learn how to:
  - Install Diodes
  - Make servo connections

- **Time Needed:** 1 hour **(depending on soldering skills)**

- **Introduction:**

  The SparkPunk kit is a sound generator in the spirit of the Atari Punk Console.

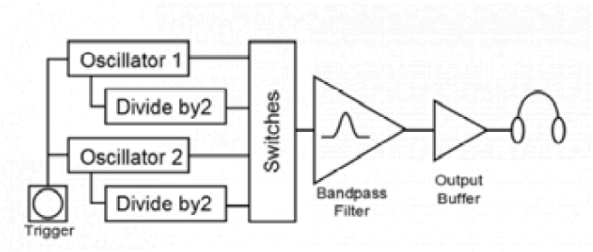
  The Atari Punk Console is a circuit that was originally designed by Forrest M Mims III, originally called the Stepped Tone Generator (in his book ***Timer, OpAmp & Optoelectronic Circuits & Projects***). It caught on with indie, lo-f, and noise musicians as a DIY project that can be played as a very simple synthesizer. Rather than simply recreating the Atari Punk, the SparkPunk is a new design that springs from a similar foundation. It starts with a dual 555 timer IC, then adds a second tone source, sub-octaves, and a bandpass filter. With all of the knobs and switches, a lot of tonal variations are possible. As a through-hole kit, the SparkPunk can also be easily extended and modified, expanding the palette of tones even further.

  - **How To Play The SparkPunk**

    The SparkPunk is a very simple synthesizer, using the common arrangement of oscillators that feed a filter. The basic recipe for playing it is to press the button, and operate the controls. Listen to the results, and adjust to taste. Explore and have fun. Some people are drawn to mellow, soothing sounds, while others prefer clangourous tones. With all of the controls, you should be able to explore both ends of the spectrum. In order to apply the SparkPunk more meaningfully, it helps to understand what's inside, and how the switches and pots control it.

  - **SparkPunk Architecture**
    The block diagram below illustrates the major functional blocks of the SparkPunk. Following things from left to right, we first see the trigger pushbutton

It is connected to the oscillators, which are allowed to run when the button is pressed - otherwise they are silent. The output of each oscillator is translated an octave lower by the sub-octave generators. The oscillator waveforms and suboctaves can be selected using the switches, which mix them together, before reaching the bandpass filter. Finally, the signal goes to the volume control and output buffer amplifiers, which allow the SparkPunk to drive small speakers or headphones. To see how each of these pieces works in more detail: SparkPunk Hook Up Guide



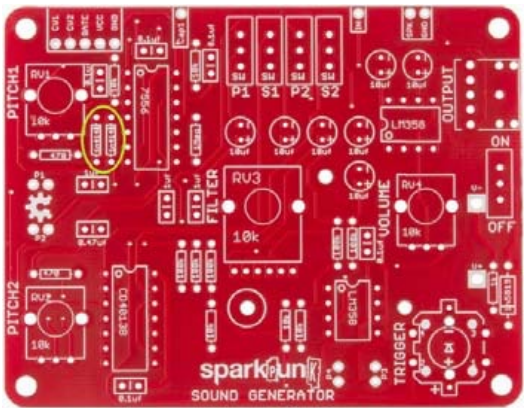
SparkPunk Architecture

Procedure: Electronic Assembly I - Diodes

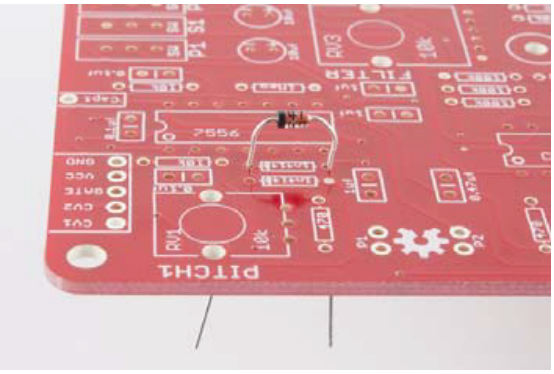
It's usually easiest to assemble if you start with the shortest components, and work up to the tallest ones. That way, you don't have work around the bulk of the larger components.

Diodes

The silicon diodes are the shortest components, so we'll start with them. Find the Silicon diodes in the kit - they have a small orange body that looks like a glass bead, with a black stripe near one end. The silicon diodes are installed side-by-side in the locations marked below. It doesn't really matter which one you start with.

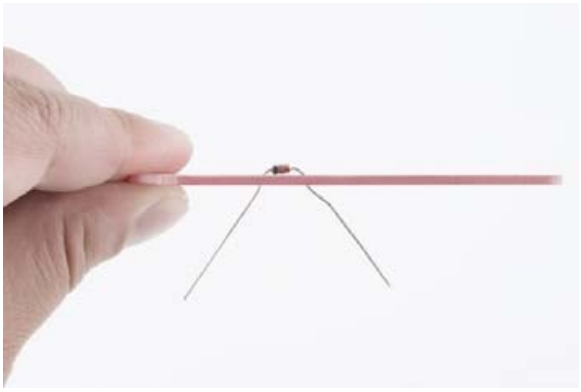


These diodes are polarized. The glass body has a black stripe on one end, which matches the white stripe on the PCB silkscreen:

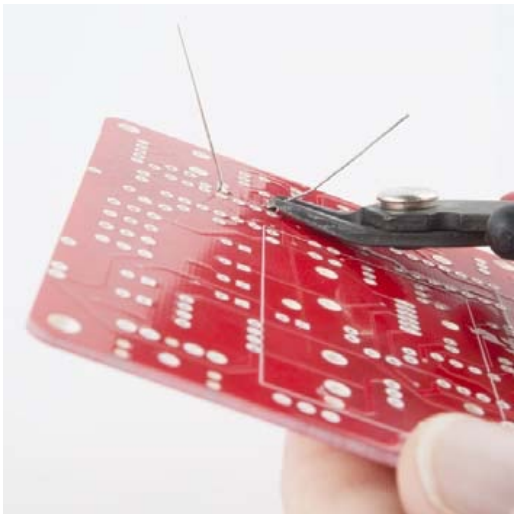


Align the stripe on the diode with the stripe on the PCB

The diode gets mounted on the top the the PCB, the side with the silkscreen outline. Bend the leads so they fit through the holes, and push them through until the body sits on top of the PCB. You can bend the legs outward slightly to hold the diode while you work.



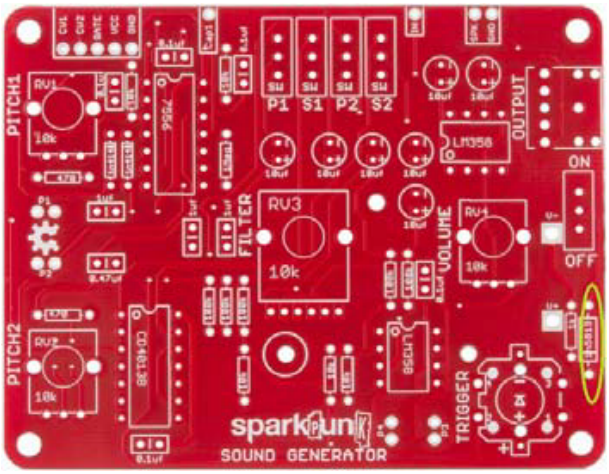
Turn the board over, solder the diode in place, then trim the excess leads near the fillet.



Install the other diode next to it. Again, it should be inserted with the stripes on both the body and PCB aligned, facing the same direction as the first diode.

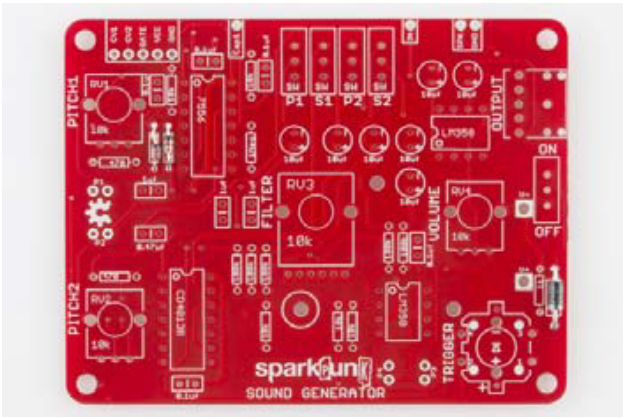
After both silicon diodes are in place, let's install the Schottky diode. (Okay, it's a tiny bit larger than the resistors, but not so large that it will interfere with later steps).

It's a black cylinder with a gray or white stripe on one end. It goes here:



Like the silicon diodes, it's polarized. Match the stripe on the body with the stripe on the PCB. Solder it in, and trim the excess leads.

With all the diodes installed, your PCB should look like this:



Before proceeding, take a moment to verify that you have the stripes on the diodes oriented correctly.

Lather, Rinse, Repeat

The pattern we've established here (insert, solder, trim) will be repeated for each of the other components on the PCB.

Part 2: Electronics Assembly **Resistors**

Teacher Resource

- Lesson Objectives

  Students will be able to:
  - Install the resistors to the PCB

- **Time Needed:** 1 hour **(Depending Soldering Skills)**

- **Procedure:** Electronic Assembly II – Resistors

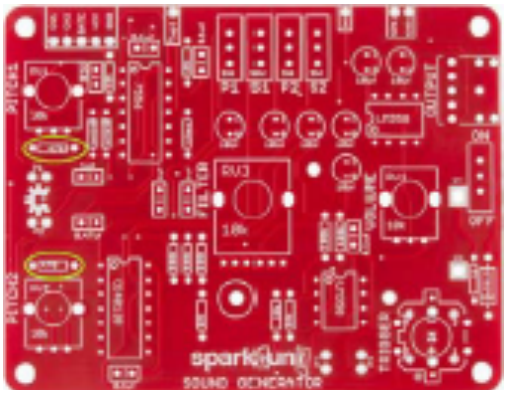
  Resistors are not polarized - they can be installed in either orientation. We'll install the resistors in order of increasing resistance value. For each resistor value, we'll insert, solder and trim the excess leads just as you did with the diodes.

  The resistor values are indicated by the colored stripes on the resistor

body. We'll note the color codes in the photo captions below, but if you'd like a more thorough explanation of how the codes work, you can find that in our Resistor Markings Tutorial.

470 Ω

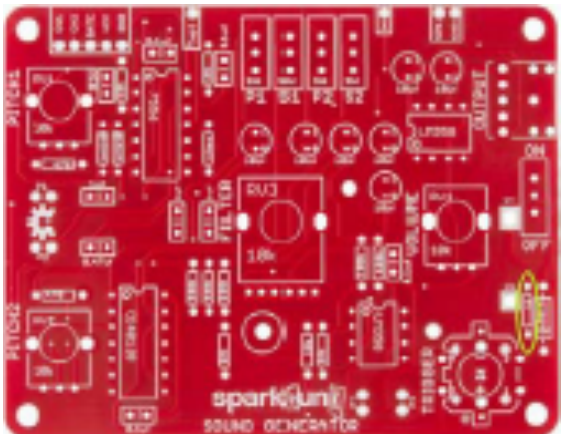
The lowest value resistors are the two 470 Ω resistors. They are located near the left edge of the PCB, as seen below:



470 Ω Resistors (Yellow - Violet - Brown - Gold)

1K Ω

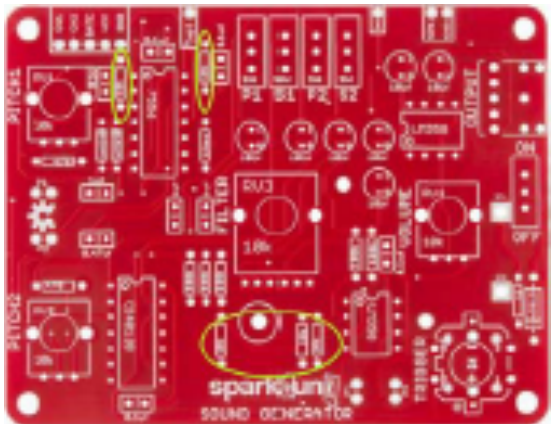
After the 470's is the 1k Ω resistor. It's located near the right edge of the board



1K Ω Resistor (Brown - Black - Red - Gold)

10K Ω

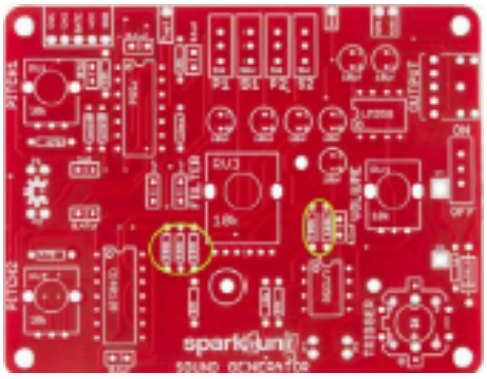
Next up are the 10K resistors. There are five of them, shown here:



10K Ω Resistors (Brown - Black - Orange - Gold)

100K Ω

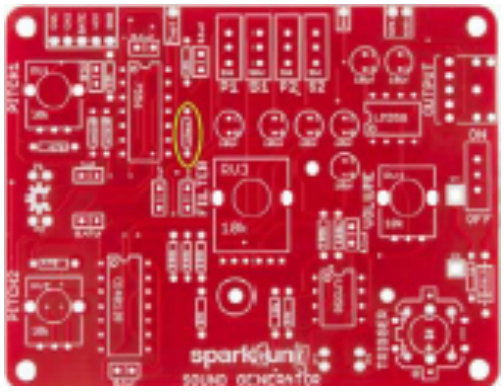
There are also five 100k resistors. They are installed near the middle of the PCB:



100K Ω Resistors (Brown - Black - Yellow - Gold)

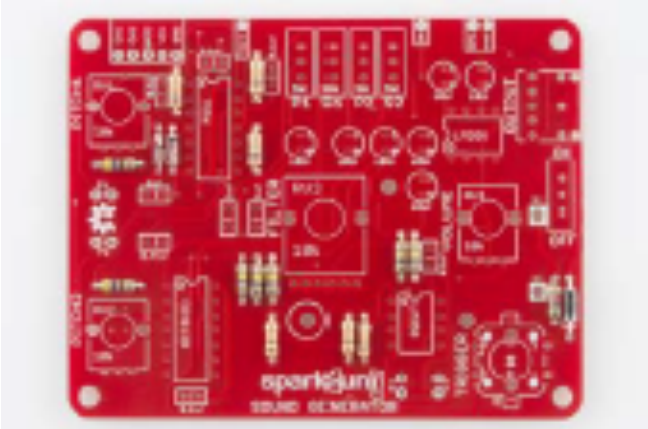
1 MΩ

Finally comes the 1 Mega-Ohm resistor. It goes here:



1M Ω Resistor (Brown - Black - Green - Gold)

At this point, all of the diodes and resistors have been installed. Your board should look like this:



Part 3: Electronic Assembly: Capacitors & ICs

Teacher Resource

Anticipated Learner Outcomes

Students will be able to:

- Install the capacitors to the PCB

◆ **Time Needed:** 1 hour **(Depending on soldering skills)**

◆ **Procedure** Capacitors and ICs

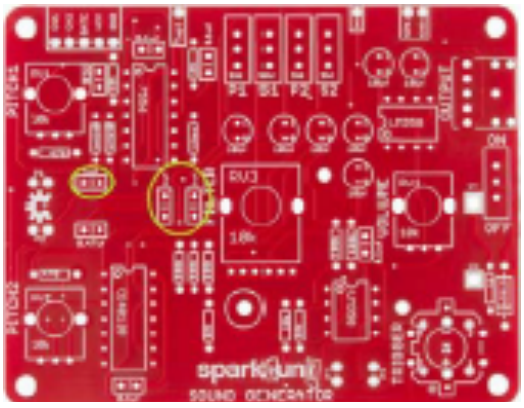
Capacitors
The next tallest components are the ceramic capacitors - they're usually little orange/yellow blobs with two leads.

Electrolytic capacitors (top), ceramic capacitors (bottom).

Like the resistors, the ceramic caps are not polarized - they can be installed facing either direction.

The values are printed on the side of the caps, but in very tiny print - in some cases, it might be so small as to be nearly invisible. A magnifying glass can help, or you can figure out which is which by counting the number of each.

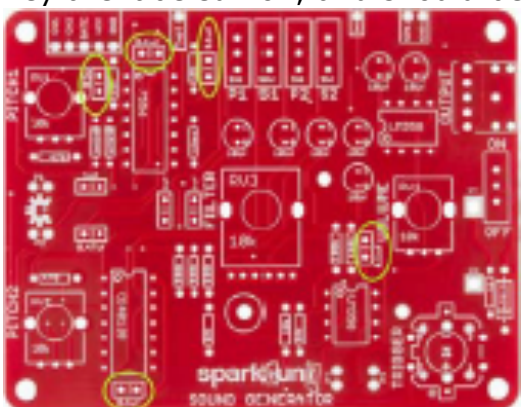
1µF Ceramic Capacitors
There are three 1µF caps, which are marked 105. They are installed here:



1 µF Ceramic Caps

0.1µF Ceramic Capacitors1µF

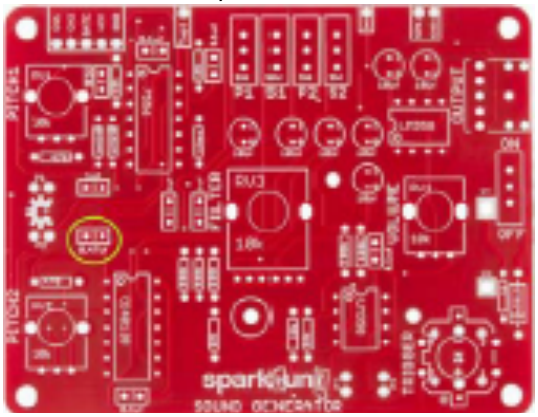
There are five 0.1µF caps. They are labeled 104, and should be located as follows:



0.1 µF Ceramic Caps

0.47µF Ceramic Capacitors

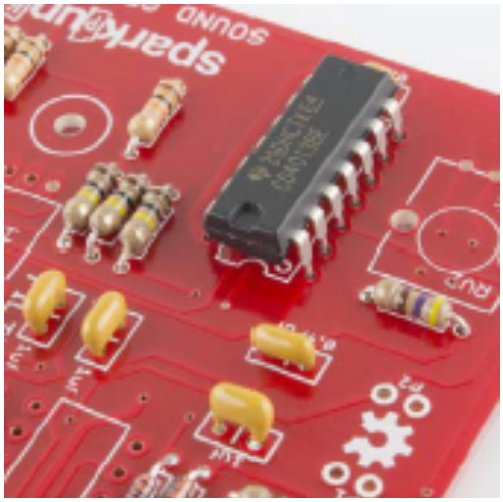
There is one 0.47 µF cap. It's marked 474, and it is located here:



0.47 µF Ceramic Cap

Integrated Circuits

At this point, we're going to take a quick detour from the capacitors and put in the integrated circuits, because they're a little shorter than the electrolytic caps.
There are four integrated circuit (IC) chips on the SparkPunk. The ICs are polarized, usually marked with a notch at one end of the chip (if there's no notch, there's a dot or divot near one corner). Again, the PCB is marked to match the component.



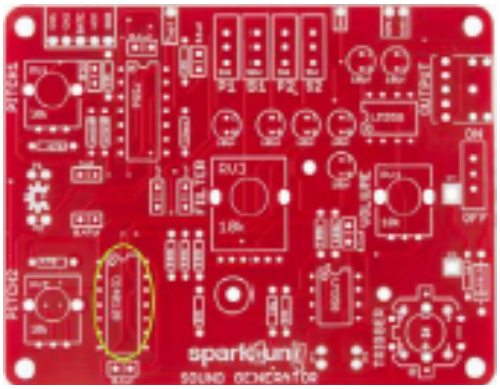
Match the half-moon in the IC body to the notch in the silkscreen.

When soldering in the chips, it can be useful to start by soldering down legs that are across from each other diagonally, to hold the chip in place while you solder the other legs.

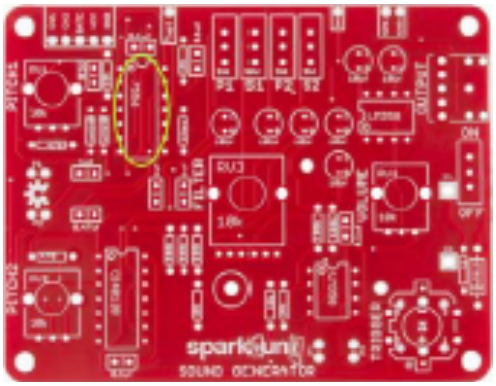
The ICM7556 and CD4013B are both 14-pin packages - take care to put each in the correct location.

Let's work from left to right, installing the chips.

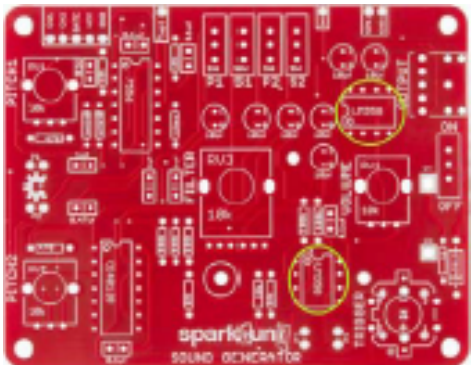
First is the CD4013B, in the lower left corner:



Following that is the ICM7556:

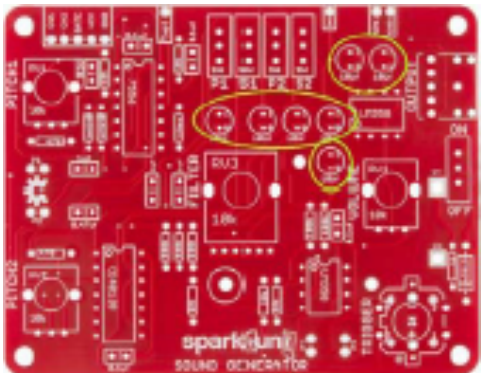


And Rounding up the ICs, lets put in the two LM358's:



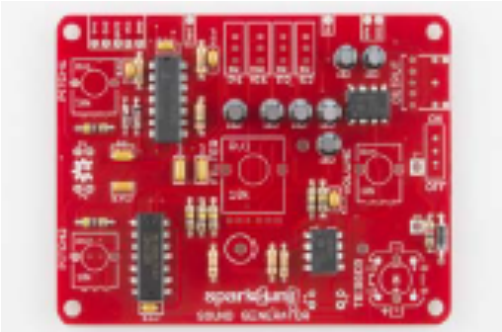
Electrolytic Caps

Electrolytic Capacitors are the small cylinders that look like tiny soda cans. They are polarized, having a positive and a negative lead. The positive lead is usually longer than the negative, and the negative side is usually marked on the body of the capacitor itself. The pads on the PCB are marked with both "+" and "-" symbols - the longer lead will go through the hole with the +. On this board, they all go in the same orientation, with the negative leg towards the top of the board.



0µf, 25V Electrolytic caps

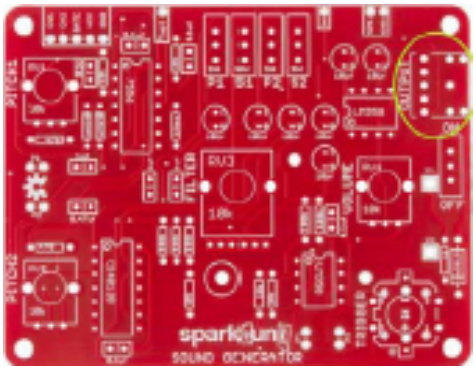
Check Your Progress
At this point, all of the shorter electronic components have been installed. Your board should now look like this:



We're almost there - there are just a few more components to install.

Mechanical Assembly
At this point we have installed all of the electronic components, and it's time to move on to the electromechanical components.

Headphone Jack
The shortest electromechanical component is the headphone jack, in the upper right corner:

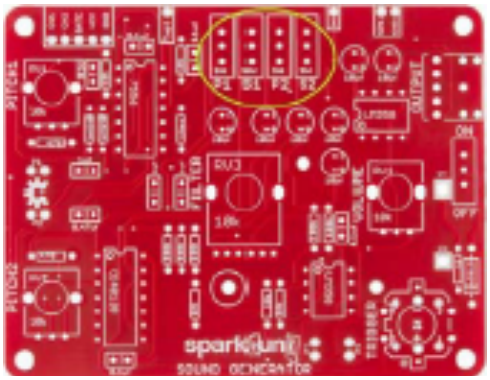


The headphone jack is placed so that the headphone socket points off the right side of the board. It also has small plastic feet that fit into holes on the PCB to help keep it in place. Be sure to solder all five metal legs down.

Switches
There are five small slide switches in the kit.

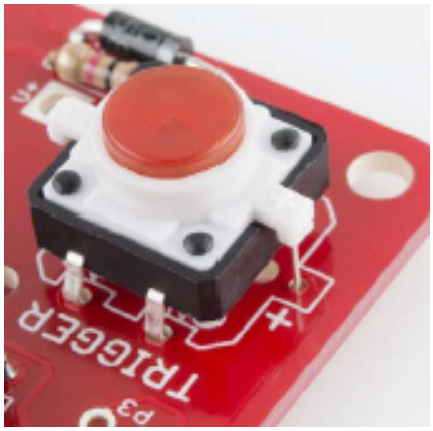
We'll save one of them for the very end, so it won't get in the way when we put in the battery box.

The first four are all located near the center of the top edge of the PCB:



The slide switches are not polarized.

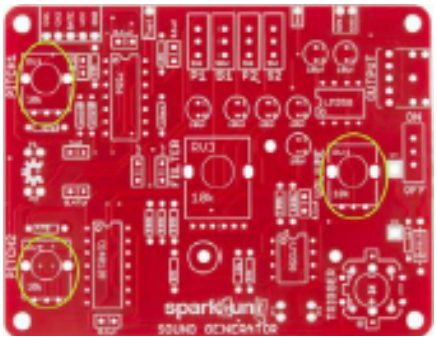
Pushbutton
After the slide switches, we put in the pushbutton:



The pushbutton contains an LED, which is polarized. Take care to identify the proper orientation - there is a small "+" on one of the white plastic tabs, which lines up with the "+" on the PCB.

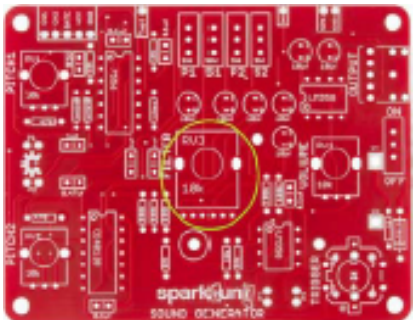
Potentiometers
The potentiometers are not polarized, but they'll only fit on the board one way.
It takes some care to get them onto the board. Start by lining up the smaller electrical legs, then push the two large tabs into the holes. If the leads or tabs have been bent in transit, they will need to be straightened out to fit the PCB. The tabs are a tight fit - gently rocking the pot from side to side can help. When inserted correctly, the back of the pot will sit flush on the top of the PCB.

When you solder them in, first solder down the tabs for stability, taking care that the pot stays flat on the board. Then solder the other connections.
We'll start with the three single-gang pots.



Three single 10K pots

Next comes the dual-ganged pot, which has 6 legs. It goes in just like the smaller pots - align the smaller legs with the holes first, then push the tabs through the board.



The dual 10K pot

Doublecheck your work

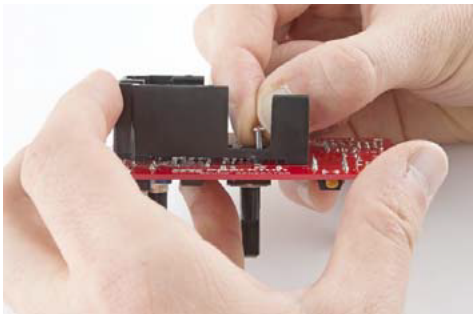
We're in the home stretch!
Before moving on, take a few moments to check your work this far. In particular, there are two things to watch out for.

1. Verify that all of the polarized components have been installed correctly.
2. Carefully inspect your solder work on the back of the board, checking for shorts and cold joints.

We're going to cover them with the battery holder in the next step, which makes it hard to see or fix any problems.

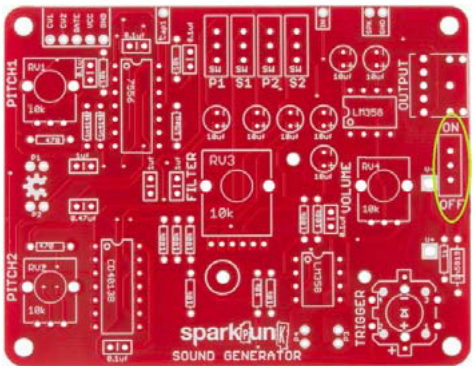
Battery box
When you're confident in your solder work, we move to the battery box. It goes on the back of the PCB:

There are a small bolt and nut in the kit, which we'll use to secure the box while you solder. Put the leads through the holes and then secure the box with the bolt. Insert the screw from inside the battery compartment, with the nut on top of the board.



It gets soldered to the front of the PCB.

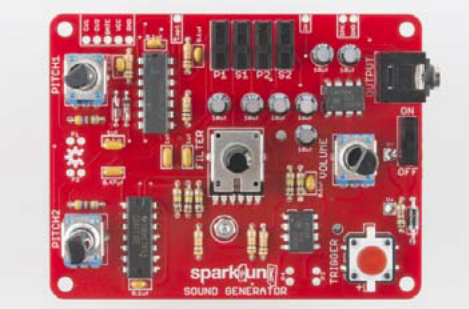
One More Switch
Finally comes the power switch, at the right edge of the PCB:



Assembly Complete

This should wrap up all of the soldering work. Take a moment to admire and double check your work. In particular, re-check the orientation of the polarized components – the diodes, ICs, electrolytic capacitors and pushbutton.

Your board should look like this:



The only remaining part should be the 9 Volt battery. We'll install it and start testing the board on the next page.

Part 4: Testing

Teacher Resource

Anticipated Learner Outcomes

Students will be able to:

- Test the SparkPunk (initial testing, sound testing, and detailed testing)
- Troubleshoot any issues

- **Time Needed:** 1 hour **(depending on need to troubleshoot)**

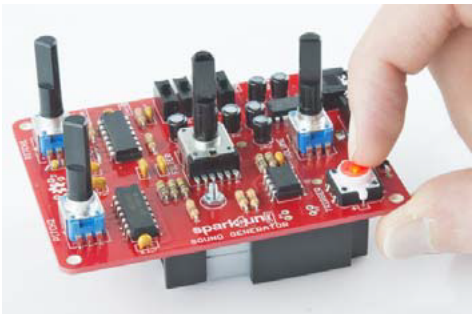
- **Procedure:** Testing

Testing

With the assembly complete, we'll move on to testing your new SparkPunk. We will test it in a couple of stages. You'll notice that as the board got assembled, a lot of the text and legends in the silkscreen got covered up by the components. The remaining text explains the function of the nearby controls. We'll denote those labels using text in boxes, like this.

Initial Testing

The first test is just a smoke test. Install the battery in the battery compartment. There are a small "+" and "-" embossed in the box that will match the corresponding marks on the battery. The battery should slide into the holder, and be held in place by the tab at the back end. If it doesn't fit easily, make sure that you've got it aligned properly.



Turn the power switch on, then press the TRIGGER button. The button should light up while you are pressing it. If it doesn't light, check the troubleshooting suggestions below.

Sound Testing

Once the button is working, we can move on to checking the sound output. To configure the test, we'll need to set all of the controls. Moving from left to right across the unit, configure the controls as follows:

- Turn PITCH1 and PITCH2 pots fully counterclockwise
- Turn on the P1 switch by sliding it upward

- Turn off the S1 , P2 and S2 switches by sliding them downward
- Put the FILTER pot at the center of it's rotation
- Turn the VOLUME pot all the way down (counterclockwise)
- Connect headphones to the OUTPUT jack
- Turn the unit ON

Now press and hold the TRIGGER button, while slowly turning up the VOLUME control. You should hear a tone that gets louder as the volume control turns. If so, congratulations! But if not, don't worry - just skip ahead to the troubleshooting section.

More Detailed Testing

Now we'll check that all of the controls are are functional. Turning the PITCH1 potentiometer should change the frequency that you are hearing. Turn the filter knob back and forth. The pitch will stay the same, but thetone will vary. The filter has a similar effect to a wah-wah pedal for electric guitar. You'll probably find that the effect is more audible for the upper half (12 o'clock to 5 o'clock) of the pot rotation. Now turn off P1 and turn on P2 . The PITCH2 control should change the frequency.

Next, work your way across the P1 , S1 , P2 and S2 switches, trying each in turn. Each should produce a different sound. You can also turn on more than one at a time to produce various combinations.

Troubleshooting

The first step in general troubleshooting is to doublecheck your work.

- Check that the polarized components are in correctly. These include:
  - The diodes
  - The pushbutton
  - Each IC chip
  - The electrolytic capacitiors
  - The battery
- Make sure that all of the solder connections have flowed correctly, with just the right amount of solder - not too little or too much.
- Verify you have your headphones or speaker connected.
- Make sure that the battery isn't dead, and the power switch is turned on. You can do so with a multimeter. If things still aren't working, try contacting Sparkfun's friendly customer support team.

All Done?

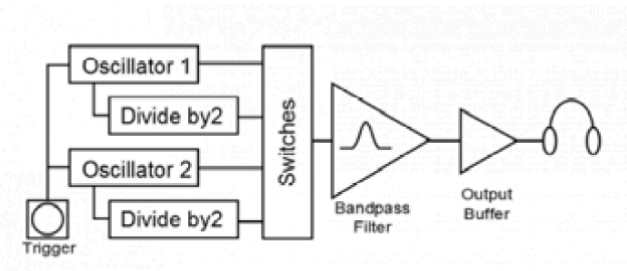
When all of the controls check out, you have a functional SparkPunk! But, it doesn't end there. In the next section, we'll explain in higher detail exactly what all these controls do and how the underlying circuit works. You can also modify and extend the SparkPunk - it's a great platform to start modifying or circuit bending. We describe a few mods you can start with in the Modifications section. Visit the SparkPunk Hook Up Manual for more information.

Student Resource:
Introduction & How to Play the SparkPunk

- **Introduction:** The SparkPunk kit is a sound generator in the spirit of the Atari Punk Console. The Atari Punk Console is a circuit that was originally designed by Forrest M Mims III, originally called the Stepped Tone Generator (in his book ***Timer, OpAmp & Optoelectronic Circuits & Projects***). It caught on with indie, lo-f, and noise musicians as a DIY project that can be played as a very simple synthesizer. Rather than simply recreating the Atari Punk, the SparkPunk is a new design that springs from a similar foundation. It starts with a dual 555 timer IC, then adds a second tone source, sub-octaves, and a bandpass filter. With all of the knobs and switches, a lot of tonal variations are possible. As a through-hole kit, the SparkPunk can also

- **How To Play The SparkPunk:** The SparkPunk is a very simple synthesizer, using the common arrangement of oscillators that feed a filter. The basic recipe for playing it is to press the button, and operate the controls. Listen to the results, and adjust to taste. Explore and have fun. Some people are drawn to mellow, soothing sounds, while others prefer clangourous tones. With all of the controls, you should be able to explore both ends of the spectrum. In order to apply the SparkPunk more meaningfully, it helps to understand what's inside, and how the switches and pots control it.

- **SparkPunk Architecture**



SparkPunk Architecture

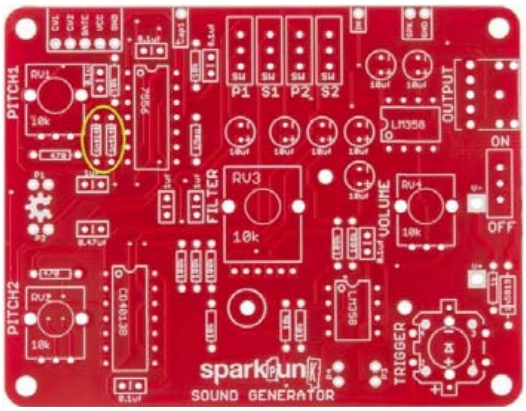
The block diagram above illustrates the major functional blocks of the SparkPunk. Following things from left to right, we first see the trigger pushbutton. It is connected to the oscillators, which are allowed to run when the button is pressed - otherwise they are silent. The output of each oscillator is translated an octave lower by the sub-octave generators. The oscillator waveforms and suboctaves can be selected using the switches, which mix them together, before reaching the bandpass filter. Finally, the signal goes to the volume control and output buffer amplifiers, which allow the SparkPunk to drive small speakers or headphones. To see how each of these pieces works in more detail: SparkPunk Hook Up Guide

Student Resource:
Part 1: Electronic Assembly I - Diodes

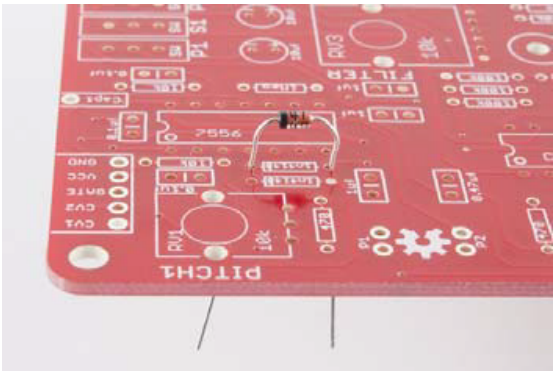
It's usually easiest to assemble if you start with the shortest components, and work up to the tallest ones. That way, you don't have work around the bulk of the larger components.

Diodes

The silicon diodes are the shortest components, so we'll start with them. Find the Silicon diodes in the kit - they have a small orange body that looks like a glass bead, with a black stripe near one end. The silicon diodes are installed side-by-side in the locations marked below. It doesn't really matter which one you start with.

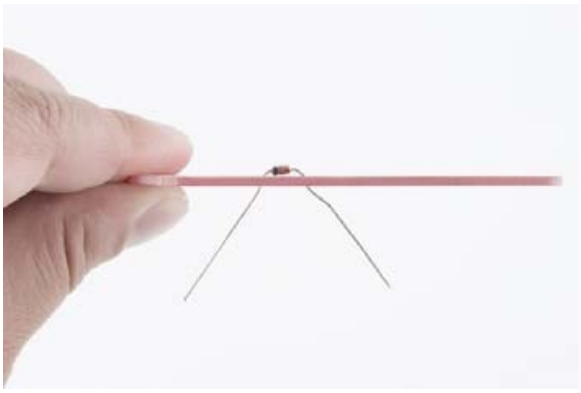


These diodes are polarized. The glass body has a black stripe on one end, which matches the white stripe on the PCB silkscreen:

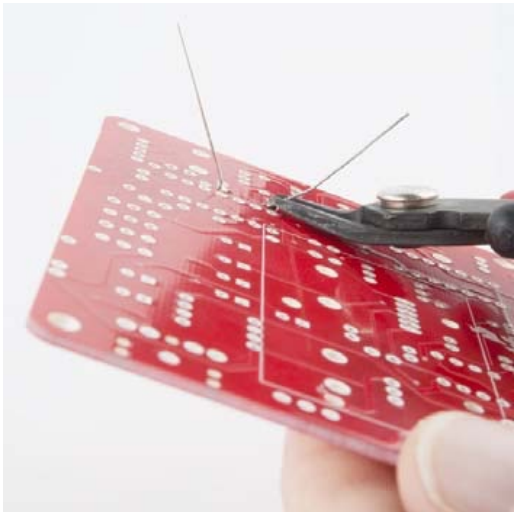


Align the stripe on the diode with the stripe on the PCB

The diode gets mounted on the top the the PCB, the side with the silkscreen outline. Bend the leads so they fit through the holes, and push them through until the body sits on top of the PCB. You can bend the legs outward slightly to hold the diode while you work.



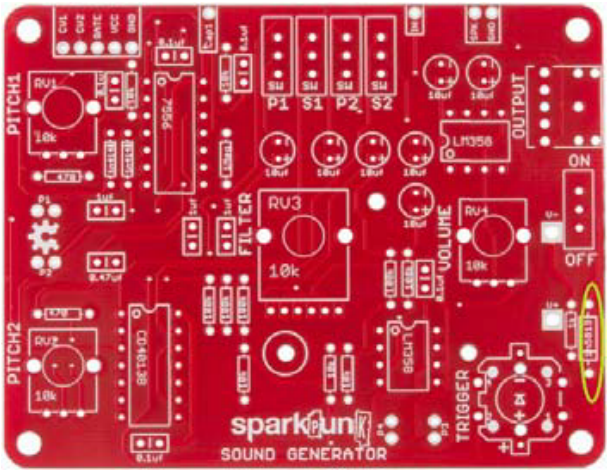
Turn the board over, solder the diode in place, then trim the excess leads near the fillet.



Install the other diode next to it. Again, it should be inserted with the stripes on both the body and PCB aligned, facing the same direction as the first diode.

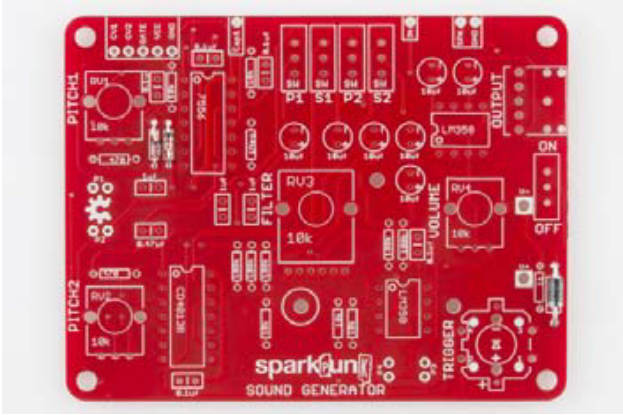
After both silicon diodes are in place, let's install the Schottky diode. (Okay, it's a tiny bit larger than the resistors, but not so large that it will interfere with later steps).

It's a black cylinder with a gray or white stripe on one end. It goes here:



Like the silicon diodes, it's polarized. Match the stripe on the body with the stripe on the PCB. Solder it in, and trim the excess leads.

With all the diodes installed, your PCB should look like this:



Before proceeding, take a moment to verify that you have the stripes on the diodes oriented correctly.

Lather, Rinse, Repeat

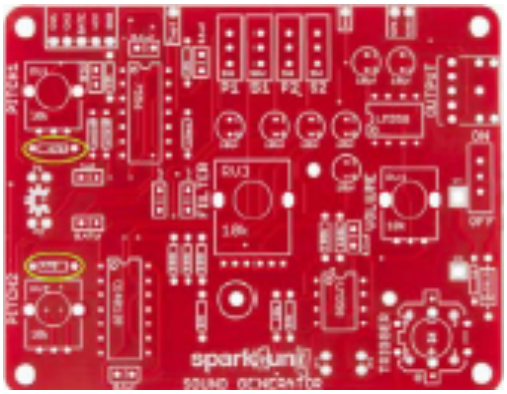
The pattern we've established here (insert, solder, trim) will be repeated for each of the other components on the PCB.

Student Resource:
Part 2: Electronic Assembly II - Resistors

Resistors are not polarized - they can be installed in either orientation. We'll install the resistors in order of increasing resistance value. For each resistor value, we'll insert, solder and trim the excess leads just as you did with the diodes.

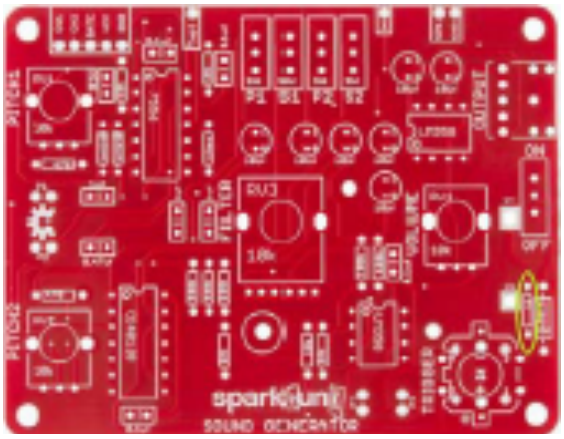
The resistor values are indicated by the colored stripes on the resistor body. We'll note the color codes in the photo captions below, but if you'd like a more thorough explanation of how the codes work, you can find that in our Resistor Markings Tutorial.

470 Ω
The lowest value resistors are the two 470 Ω resistors. They are located near the left edge of the PCB, as seen below:



470 Ω Resistors (Yellow - Violet - Brown - Gold)

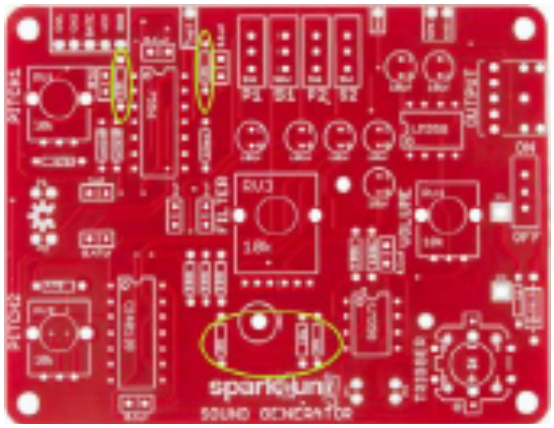
1K Ω
After the 470's is the 1k Ω resistor. It's located near the right edge of the board



1K Ω Resistor (Brown - Black - Red - Gold)

10K Ω

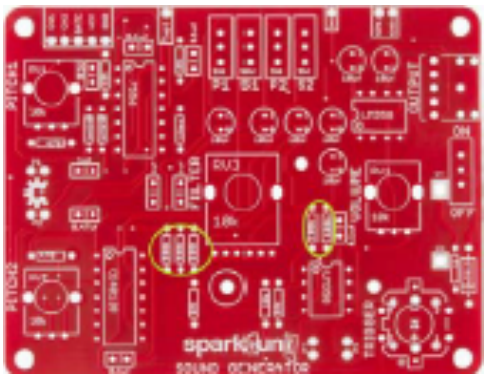
Next up are the 10K resistors. There are five of them, shown here:



10K Ω Resistors (Brown - Black - Orange - Gold)

100K Ω

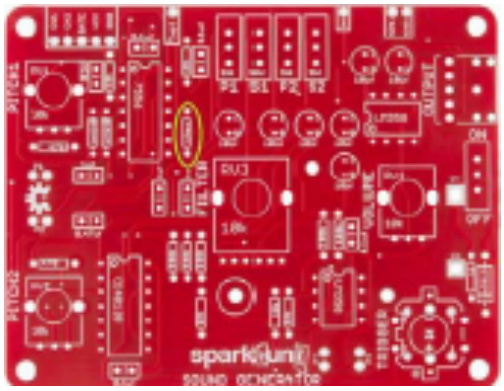
There are also five 100k resistors. They are installed near the middle of the PCB:



100K Ω Resistors (Brown - Black - Yellow - Gold)

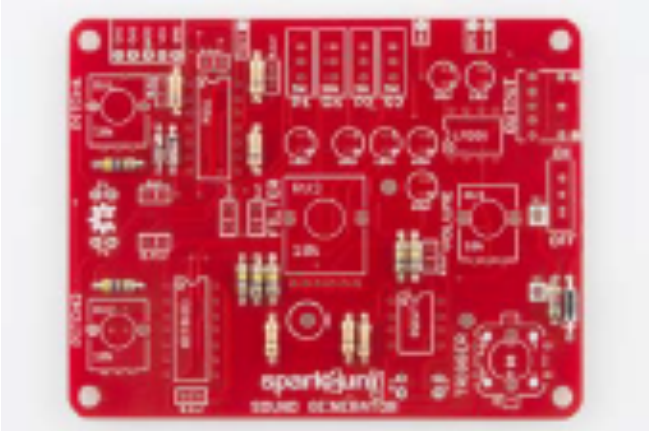
1 MΩ

Finally comes the 1 Mega-Ohm resistor. It goes here:



1M Ω Resistor (Brown - Black - Green - Gold)

At this point, all of the diodes and resistors have been installed. Your board should look like this:



Student Resource: Part 3: Electronic Assembly III- Capacitors and Integrated Circuits (IC)

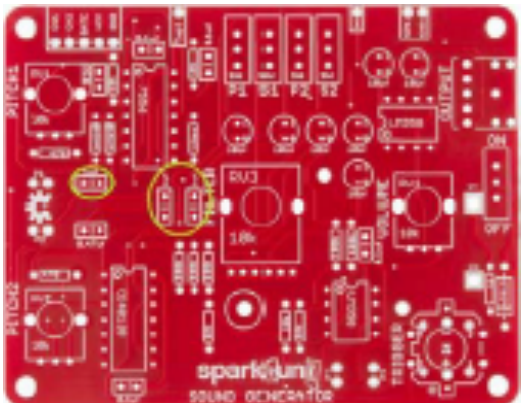
Capacitors
The next tallest components are the ceramic capacitors - they're usually little orange/yellow blobs with two leads.

Electrolytic capacitors (top), ceramic capacitors (bottom).

Like the resistors, the ceramic caps are not polarized - they can be installed facing either direction.

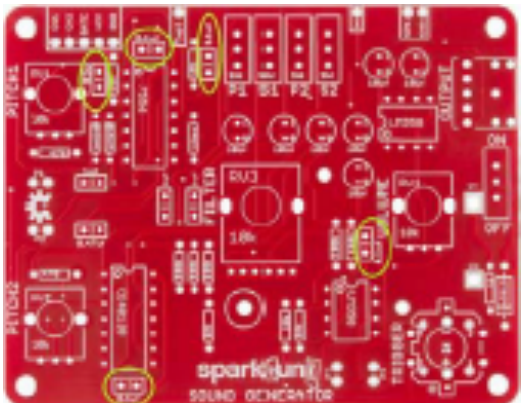
The values are printed on the side of the caps, but in very tiny print - in some cases, it might be so small as to be nearly invisible. A magnifying glass can help, or you can figure out which is which by counting the number of each.

1µF Ceramic Capacitors
There are three 1µF caps, which are marked 105. They are installed here:



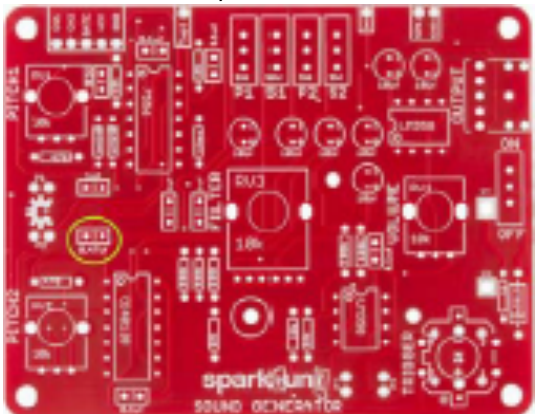
1 µF Ceramic Caps

0.1µF Ceramic Capacitors1µF
There are five 0.1µF caps. They are labeled 104, and should be located as follows:



0.1 µF Ceramic Caps

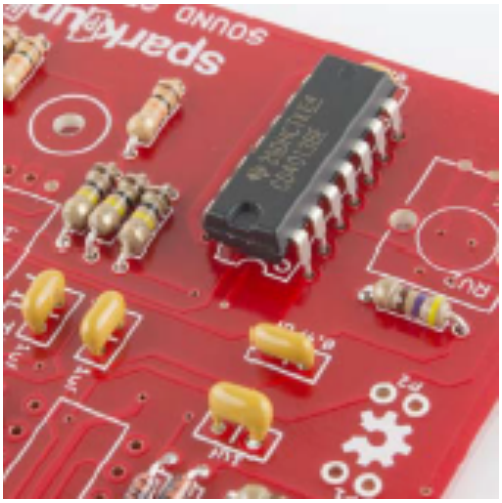
0.47µF Ceramic Capacitors
There is one 0.47 µF cap. It's marked 474, and it is located here:



0.47 µF Ceramic Cap

Integrated Circuits (IC)

At this point, we're going to take a quick detour from the capacitors and put in the integrated circuits, because they're a little shorter than the electrolytic caps. There are four integrated circuit (IC) chips on the SparkPunk. The ICs are polarized, usually marked with a notch at one end of the chip (if there's no notch, there's a dot or divot near one corner). Again, the PCB is marked to match the component. Match the half-moon in the IC body to the notch in the silkscreen.

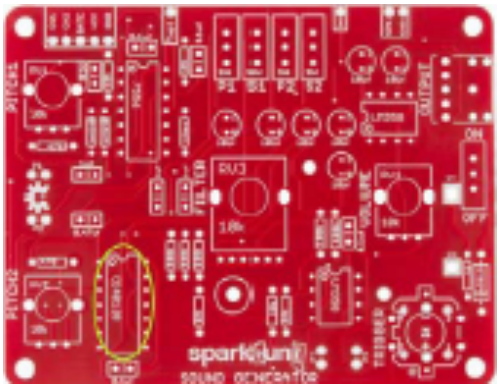


When soldering in the chips, it can be useful to start by soldering down legs that are across from each other diagonally, to hold the chip in place while you solder the other legs.

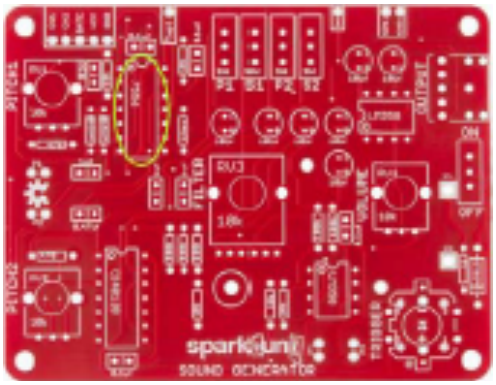
The ICM7556 and CD4013B are both 14-pin packages - take care to put each in the correct location.

Let’s work from left to right, installing the chips.

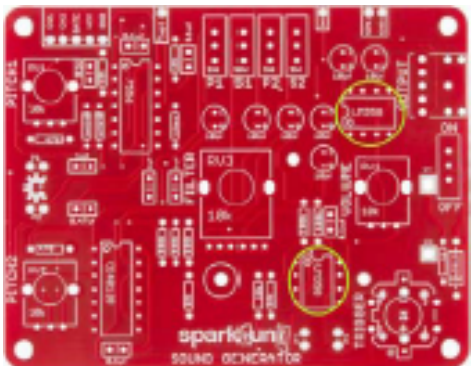
First is the CD4013B, in the lower left corner:



Following that is the ICM7556:

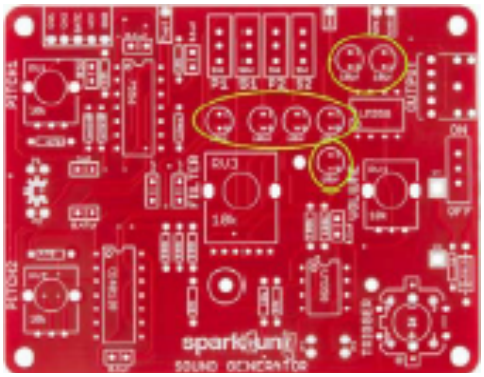


And Rounding up the ICs, lets put in the two LM358’s:



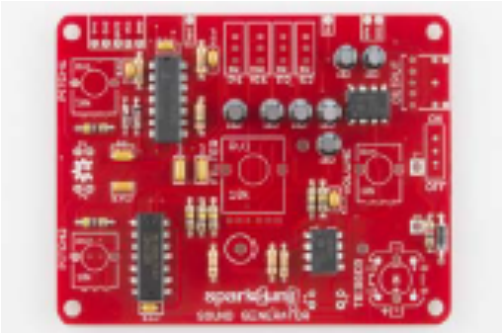
Electrolytic Caps

Electrolytic Capacitors are the small cylinders that look like tiny soda cans. They are polarized, having a positive and a negative lead. The positive lead is usually longer than the negative, and the negative side is usually marked on the body of the capacitor itself. The pads on the PCB are marked with both "+" and "-" symbols - the longer lead will go through the hole with the +. On this board, they all go in the same orientation, with the negative leg towards the top of the board.



0µf, 25V Electrolytic caps

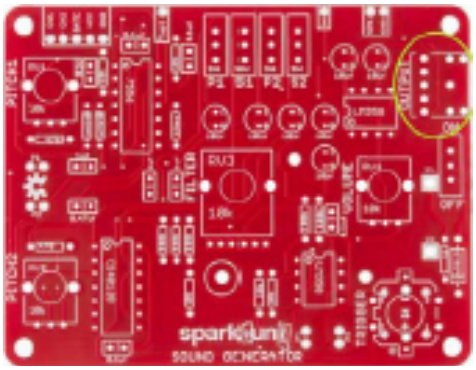
Check Your Progress
At this point, all of the shorter electronic components have been installed. Your board should now look like this:



We're almost there - there are just a few more components to install.

Mechanical Assembly
At this point we have installed all of the electronic components, and it's time to move on to the electromechanical components.

Headphone Jack
The shortest electromechanical component is the headphone jack, in the upper right corner:

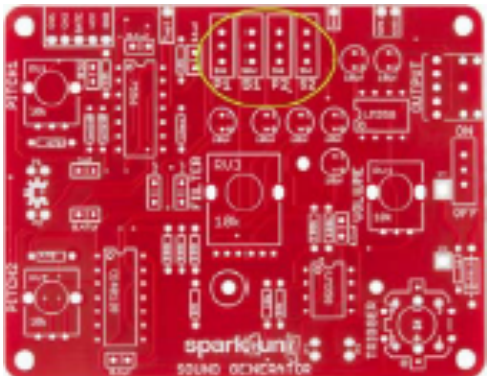


The headphone jack is placed so that the headphone socket points off the right side of the board. It also has small plastic feet that fit into holes on the PCB to help keep it in place. Be sure to solder all five metal legs down.

Switches
There are five small slide switches in the kit.

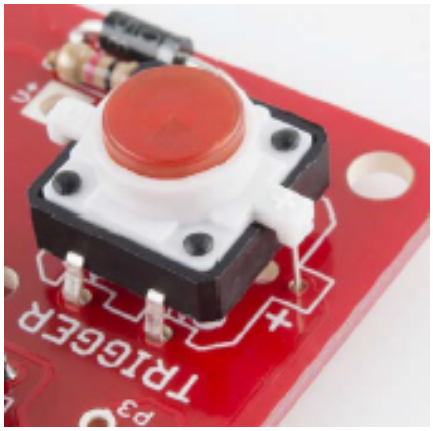
We'll save one of them for the very end, so it won't get in the way when we put in the battery box.

The first four are all located near the center of the top edge of the PCB:



The slide switches are not polarized.

Pushbutton
After the slide switches, we put in the pushbutton:

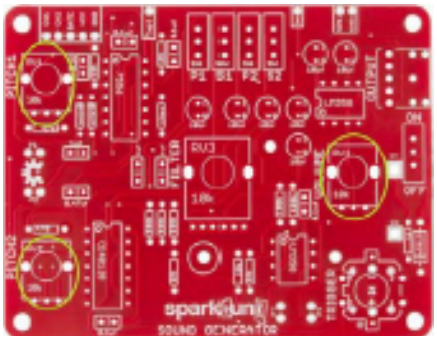


The pushbutton contains an LED, which is polarized. Take care to identify the proper orientation - there is a small "+" on one of the white plastic tabs, which lines up with the "+" on the PCB.

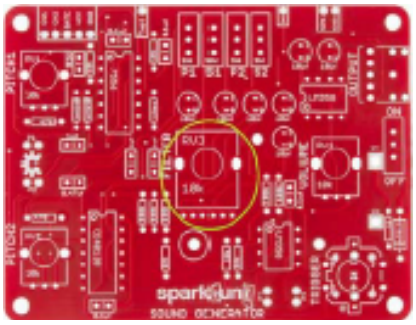
Potentiometers

The potentiometers are not polarized, but they'll only fit on the board one way.
It takes some care to get them onto the board. Start by lining up the smaller electrical legs, then push the two large tabs into the holes. If the leads or tabs have been bent in transit, they will need to be straightened out to fit the PCB. The tabs are a tight fit - gently rocking the pot from side to side can help. When inserted correctly, the back of the pot will sit flush on the top of the PCB.

When you solder them in, first solder down the tabs for stability, taking care that the pot stays flat on the board. Then solder the other connections.
We'll start with the three single-gang pots.


Three single 10K pots

Next comes the dual-ganged pot, which has 6 legs. It goes in just like the smaller pots - align the smaller legs with the holes first, then push the tabs through the board.


The dual 10K pot

Doublecheck your work

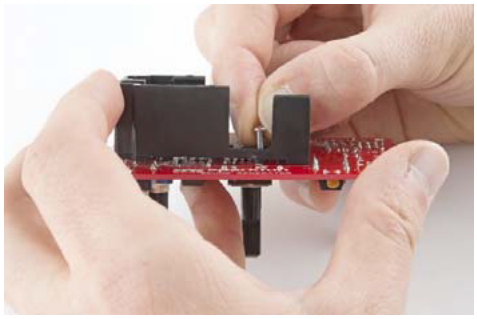
We're in the home stretch!
Before moving on, take a few moments to check your work this far. In particular, there are two things to watch out for.

1. Verify that all of the polarized components have been installed correctly.
2. Carefully inspect your solder work on the back of the board, checking for shorts and cold joints.

We're going to cover them with the battery holder in the next step, which makes it hard to see or fix any problems.

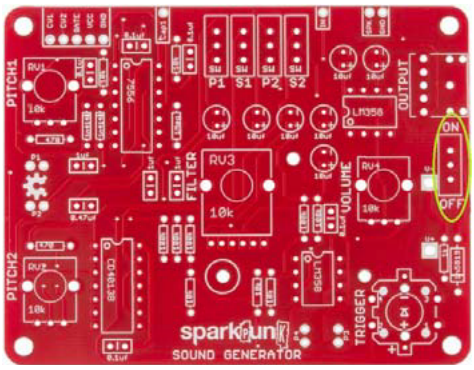
Battery box
When you're confident in your solder work, we move to the battery box. It goes on the back of the PCB:

There are a small bolt and nut in the kit, which we'll use to secure the box while you solder. Put the leads through the holes and then secure the box with the bolt. Insert the screw from inside the battery compartment, with the nut on top of the board.



It gets soldered to the front of the PCB.

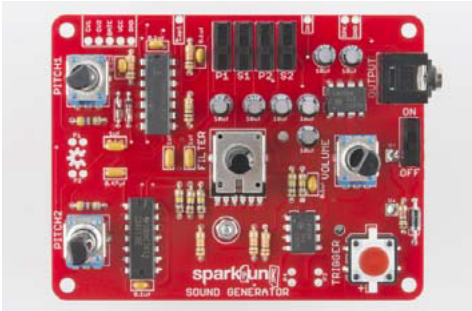
One More Switch
Finally comes the power switch, at the right edge of the PCB:



Assembly Complete

This should wrap up all of the soldering work. Take a moment to admire and double check your work. In particular, re-check the orientation of the polarized components – the diodes, ICs, electrolytic capacitors and pushbutton.

Your board should look like this:

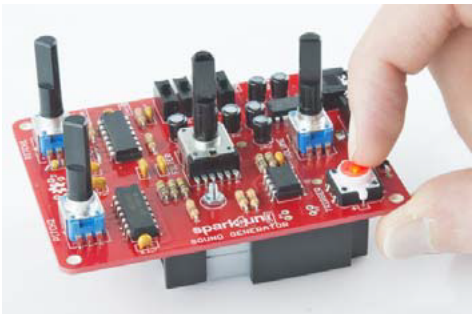


The only remaining part should be the 9 Volt battery. We'll install it and start testing the board on the next page.

Student Resource:
Part 4: Testing

Testing
With the assembly complete, we'll move on to testing your new SparkPunk. We will test it in a couple of stages. You'll notice that as the board got assembled, a lot of the text and legends in the silkscreen got covered up by the components. The remaining text explains the function of the nearby controls. We'll denote those labels using text in boxes, like this.

Initial Testing
The first test is just a smoke test. Install the battery in the battery compartment. There are a small "+" and "-" embossed in the box that will match the corresponding marks on the battery. The battery should slide into the holder, and be held in place by the tab at the back end. If it doesn't fit easily, make sure that you've got it aligned properly.



Turn the power switch on, then press the TRIGGER button. The button should light up while you are pressing it. If it doesn't light, check the troubleshooting suggestions below.

Sound Testing
Once the button is working, we can move on to checking the sound output. To configure the test, we'll need to set all of the controls. Moving from left to right across the unit, configure the controls as follows:

- Turn PITCH1 and PITCH2 pots fully counterclockwise
- Turn on the P1 switch by sliding it upward
- Turn off the S1 , P2 and S2 switches by sliding them downward
- Put the FILTER pot at the center of it's rotation
- Turn the VOLUME pot all the way down (counterclockwise)
- Connect headphones to the OUTPUT jack
- Turn the unit ON

Now press and hold the TRIGGER button, while slowly turning up the VOLUME control. You should hear a tone that gets louder as the volume control turns. If so, congratulations! But if not, don't worry - just skip ahead to the troubleshooting section.

More Detailed Testing

Now we'll check that all of the controls are are functional. Turning the PITCH1 potentiometer should change the frequency that you are hearing. Turn the filter knob back and forth. The pitch will stay the same, but thetone will vary. The filter has a similar effect to a wah-wah pedal for electric guitar. You'll probably find that the effect is more audible for the upper half (12 o'clock to 5 o'clock) of the pot rotation. Now turn off P1 and turn on P2 . The PITCH2 control should change the frequency.

Next, work your way across the P1 , S1 , P2 and S2 switches, trying each in turn. Each should produce a different sound. You can also turn on more than one at a time to produce various combinations.

Troubleshooting

The first step in general troubleshooting is to doublecheck your work.

- Check that the polarized components are in correctly. These include:
  - The diodes
  - The pushbutton
  - Each IC chip
  - The electrolytic capacitiors
  - The battery
- Make sure that all of the solder connections have flowed correctly, with just the right amount of solder - not too little or too much.
- Verify you have your headphones or speaker connected.
- Make sure that the battery isn't dead, and the power switch is turned on. You can do so with a multimeter. If things still aren't working, try contacting Sparkfun's friendly customer support team.

All Done?

When all of the controls check out, you have a functional SparkPunk! But, it doesn't end there. In the next section, we'll explain in higher detail exactly what all these controls do and how the underlying circuit works. You can also modify and extend the SparkPunk - it's a great platform to start modifying or circuit bending. We describe a few mods you can start with in the Modifications section. Visit the SparkPunk Hook Up Manual for more information.

Student Worksheet: Reflection

Did you get your SparkPunk to work?

What problem(s) did you encounter and how did you work through them?

Share any new insight(s) you may have had along the way?

Teacher Resource: Alignment to Curriculum Frameworks

This lesson touches the standards listed but not with equal level of alignment (meaning SOME elements of the standard may be addressed and in other cases ALL of it will be addressed). We would like your help to better improve our alignments. Please email us with your feedback at tryengieering@ieee.org.

◆ Next Generation Science Standards (NGSS)

MS- PS4 Waves and their Applications in Technology for Information Transfer.
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

◆ Common Core State Standards for Mathematics

CCSS MP2: Reason abstractly and quantitatively. Mathematically proficient students make sense of quantities and their relationships in problem situations.

◆ ITEEA Standards for Technological Literacy – All Ages

Standard 3.2: Students will develop an understanding of the Nature of Technology and Society of the core concepts of technology.

◆ ISTE Technology Standards for Students

ISTE Standards for Students

- **Computational Thinker:** Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.