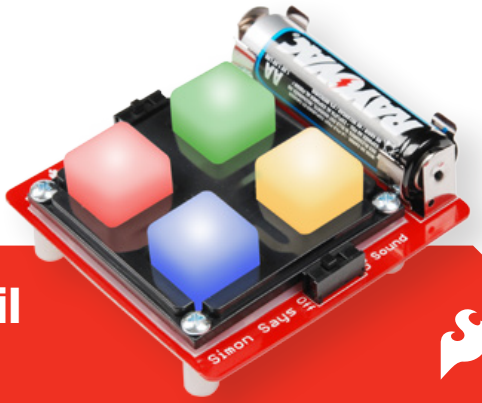
Learn to Solder: Simon Says Stencil

Kit Information & Instructions



This is considered an intermediate kit for people who have soldered through-hole components before and wish to learn how to reflow surface mount components. This kit comes with a preprogrammed ATmega328. All parts are listed below.

Kit includes:

- Tweezers
- NCP1402 IC
- 10k Ohm Resistor
- 47µF Capacitor
- 10µF Capacitor
- 0.1µF Capacitor (qty: 2)
- MBRA140 Diode
- 22µH Inductor
- 330 Ohm Resistors (qty: 4)
- Pre-programmed ATmega328 TQFP IC
- Simon Stencil
- Simon PCB (w/outer frame)
- Buzzer
- LEDs (qty: 4)
- Battery Clips (qty: 2)
- Switches (qty: 2)
- Screws (qty: 4)
- Standoffs (qty: 4)
- Bezel Frame
- Button Pad
- Battery
- Card
- Solder Paste (Lead Free)

Additional Tools Needed:

- Hot-air station/gun
- Soldering iron + accessories
- Masking tape
- Monocle

TABLE OF CONTENTS

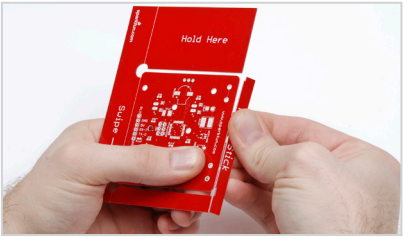
Check out our Glossary of Terms section on page 52. It's full of terms we recommend you reference when you are building your Learn to Solder: Simon Says Stencil kit!

SETUP

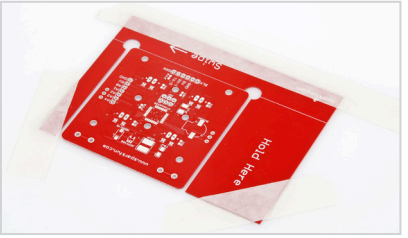
[STEPS 1 TO 10]

DO NOT BREAK ANYTHING APART UNTIL TOLD TO DO SO

1. Break off paste stick.



2. Choose a smooth, flat surface. Tape down the PCB. We recommend masking tape.



3 Open paste jar (use tweezers to tear off plastic)

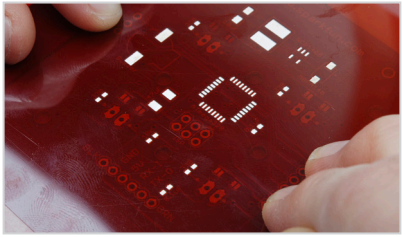
4 When you first open the paste, you will need to mix it with the paste stick. When using lead-free solder paste, the consistency is very important. There is a thin layer of flux on top of the paste when you first open it. This helps the tin and other metals in the paste flow like lead solder.

5 The card included is for applying the paste to the PCB. We will refer to it as the spatula. Using the paste stick, apply a small bead of paste to the edge of the spatula.

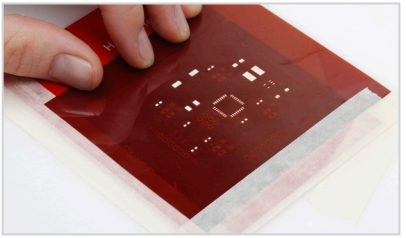
6 Set it aside somewhere where it won't get smudged. We recommend using the SparkFun box.

7 Close up the paste once you have extracted all that you will need so that it doesn't dry out.

8 Align stencil on top of PCB. Make sure all the pads lineup.



9 You can either hold the stencil with your hand, or you can tape down the side you would normally hold. Make sure there is plenty of pressure all along the edge of the stencil. You don't want it to move around while you're pasting.



10 With your free hand, grab the spatula with paste on it. It's time to paste!

PASTING [STEPS 1 TO 8]

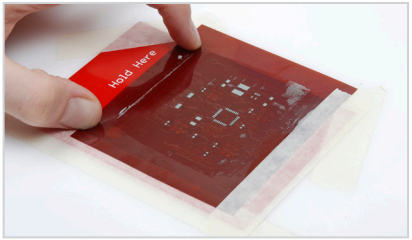
1. First swipe: Take your spatula, with the paste side down, and set it near the edge that you're holding down (or taped down). On this swipe we are going to apply paste to the stencil so that is covers all of the pads.

2. You want the card to be at a 45-degree angle. With minimum pressure, swipe the spatula across the stencil. Be sure to fill every hole on the stencil. It's ok if the stencil is mostly covered in paste. **MAKE SURE THE STENCIL DOESN'T MOVE WHILE YOU'RE SWIPING.**

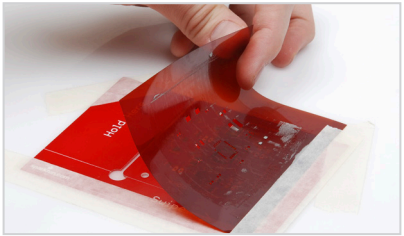
3. Second swipe: Put your spatula back in the starting position. On this swipe we are going to remove the excess paste from the stencil so that only the paste on our pads remains.

4. The spatula should be at a steeper angle this time, about 75-80 degrees. With more pressure than the last swipe, pull the spatula across the the stencil, scraping off the the top layer of paste. **AGAIN, MAKE SURE THE STENCIL DOESN'T MOVE.**

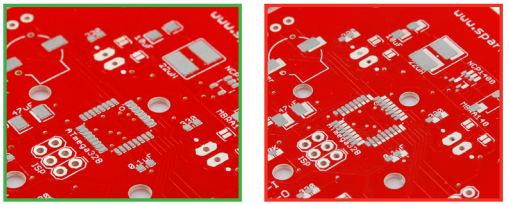
5 The goal is to get paste on all the pads in one try (two swipes). However, you may have missed a pad or two. Look over the stencil to ensure that there is a sufficient amount of paste on all the pads. If this isn't the case, please see page 48 for instructions on how to clean your board before repeating steps 1-4. Be careful. The more swipes it takes, the more likely you are to move the stencil and smudge your paste job.



6 We aren't out of the woods yet. Removing the stencil is a very dangerous step. If done incorrectly, you could ruin your beautiful paste job. The stencil should still be held down on one side. Starting from the end opposite that side, peel back the stencil very carefully. Do not shift the stencil. Peel all the way until it is no longer touching the paste.

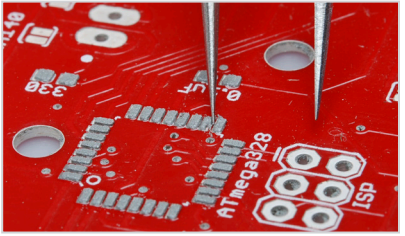


GOOD BAD



7 If your paste job looks like the **GOOD** example above, then we are ready to move on to placing the parts. If your first try didn't turn out as you had hoped, don't worry. It's easy to clean off the stencil and PCB and start over.

8 Along with not having enough paste, you could encounter the problem of having applied too much paste. If you use too much pressure on your first swipe, paste can get pushed underneath the stencil and cause smudging between the pads. If this has happened to you, please see page 48 for instructions on how to clean your board and start over. If there are just a few spots that have a smudge, you can use your tweezers to scrape away the excess paste in between the pads.



PLACING COMPONENTS [STEPS 1 TO 8]

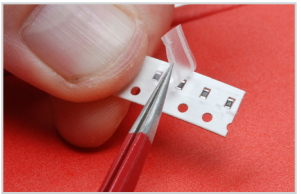
Now you are ready to start placing the 330 Resistors on the board.

1. It is very important that you place the parts in a timely manner after pasting the board. Solder paste can dry out, and it will lose its ability to melt and flow well. Do not let your board sit for more than an hour.

2. It is also very important to be careful while your paste is wet. It is very easy to accidentally smudge your paste job while placing parts. Long hair and sleeves are among the most likely culprits. Tie up anything loose that will drag on the PCB.

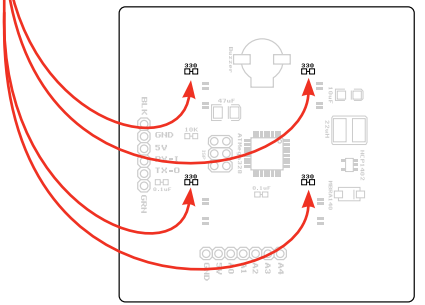
3. Working with surface-mount components is much more difficult than through-hole components. For starters, they are a lot smaller than through-hole parts. Be careful, as these tiny parts have a tendency to fly off and get lost. If you do lose a part, there are spare parts included with this kit.

4. Identify the components before placing. Use the tweezers to pull the film off the tape. Take the parts off the tape, and keep them organized. Do one part at a time so they don't get mixed up.

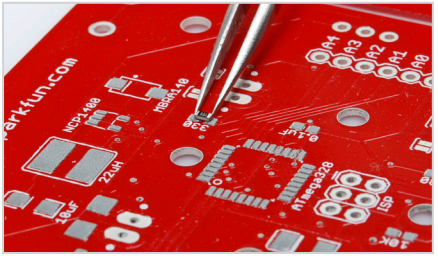


5. Locate the **330 Resistors**

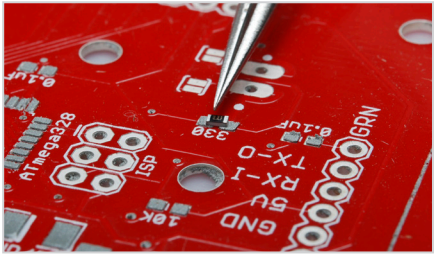
6. Locate the **330 Resistor** positions on the board. These resistors are not polarized. However, they do have a value marking on the top side. Make sure the marking is facing up.



7 Using the tweezers, push one of the **330 Resistors** lightly into the paste. Make sure it's in one of the four correct spots.



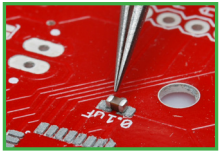
8 Using the tweezers, use the same method to place the remaining three **330 Resistors** in the correct spots.



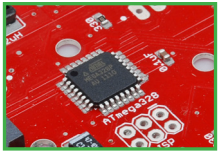
COMPONENT PLACEMENT

Before you continue to STEP 9, see below for examples of component placement.

GOOD

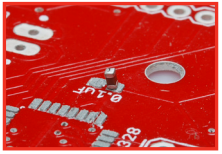


GOOD

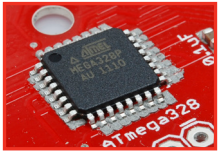


Good placement is when the SMD component is laying flat in the correct spot.

BAD



BAD



Bad placement is if the SMD component is rotated, off center, or has one side lifted. Redo the placement of the component until it looks good.

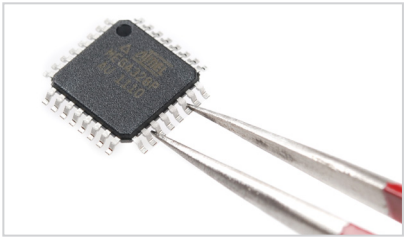
CONTINUE WITH THE **BOTTOM OF THE BOARD** [STEPS 9 TO 17]

Now that you've successfully placed down the 330 Resistors, use the same method to place the following components.

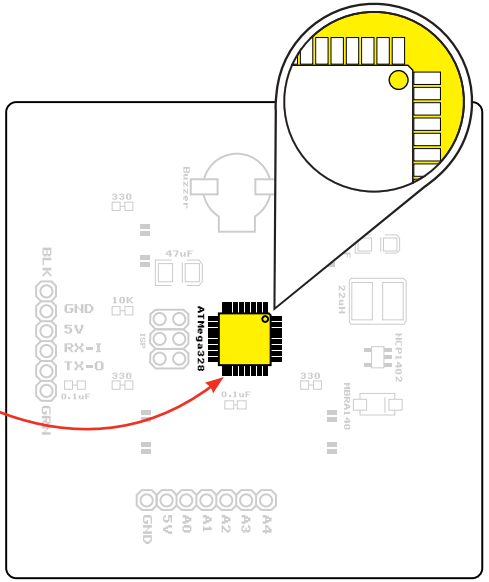
Steps highlighted in yellow represent a polarized component. Pay special attention to the component's markings indicating how to place it on the board.

9 ATMega328

ATMega328 Microcontroller The ATMega328 is the hardest part to place. Match up the circle on the IC with that on the PCB's silkscreen. Please see below for an example of how to hold the IC with the tweezers.



BOTTOM OF BOARD



10 10uF Capacitor ⚠

10uF Capacitor The white end of the capacitor should point towards the rounded end on the PCB's silkscreen.

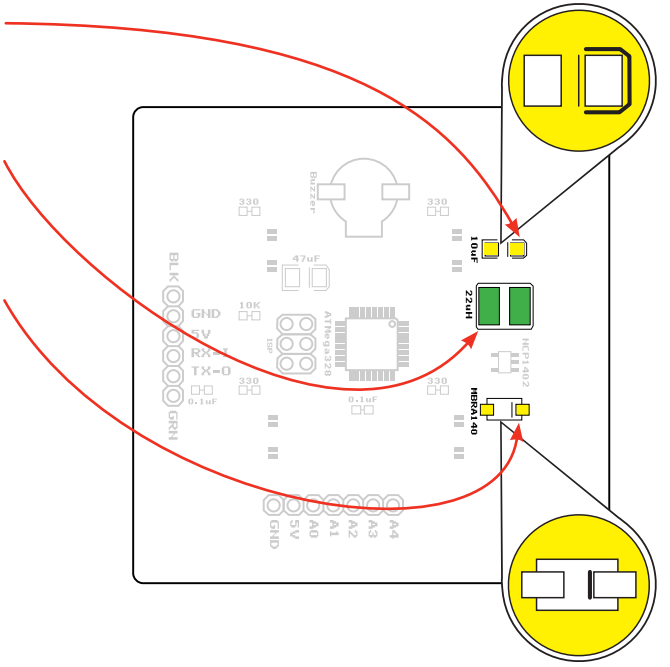
11 22uH Inductor

22uH Inductor When placing this component, make sure the inductor remains inside its white outline.

12 MBRA140 Diode ⚠

MBRA140 Diode Before placing, double-check that the white line on the diode matches the line on the PCB's silkscreen. The white line is similar to the line on the 10uF capacitor in step 10.

BOTTOM OF BOARD



Remember, components highlighted yellow are polarized.

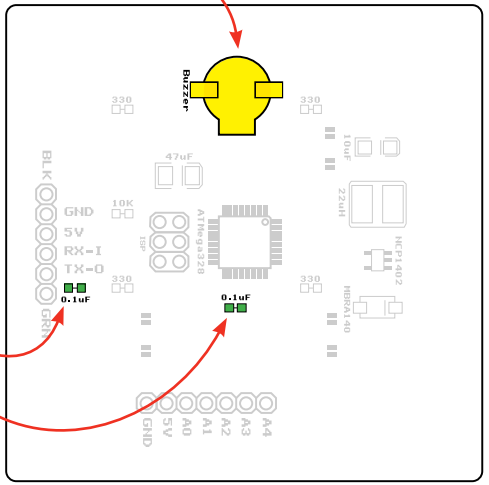
13 Buzzer

Buzzer Alignment of the buzzer is very important. You want to ensure the buzzer is centered and laying flat against the board.

14 0.1uF Capacitors

0.1uF Capacitors Ceramic capacitors like these are not polarized. They don't have a value marking. This means their orientation is not important.

BOTTOM OF BOARD



Remember, components highlighted yellow are polarized.

15 47uF Capacitor

47uF Capacitor The white line on the capacitor should point towards the rounded end on the PCB's silkscreen.

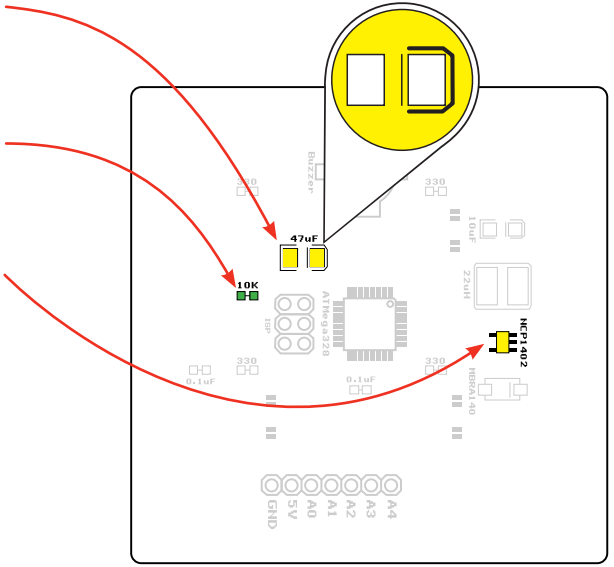
16 10K Resistor

10K Resistor Just like the 330 resistors, these are not polarized. Make sure the writing on the part ('103') is facing up.

17 NCP1402

NCP1402 Be sure to match up the legs with the pads on the PCB. This component is polarized.

BOTTOM OF BOARD



Remember, components highlighted yellow are polarized.

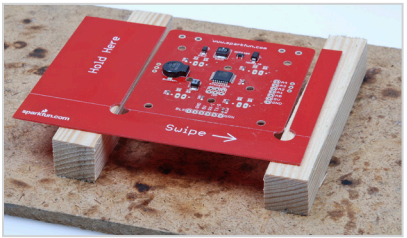
REFLOWING YOUR PCB

[STEPS 1 TO 7]

1. Now it is time to reflow your parts onto the PCB. There are many ways to do this. You could use a modified toaster oven. You could use a skillet or hot-plate. Or, you could use a hot-air rework station or a heat gun. Here we will be covering the hot-air method.

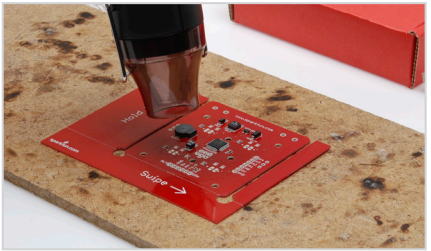
2. Turn on your SparkFun heaterizer (NOT INCLUDED) and let it warm up for about a minute.

3. Place your board onto a heat-safe surface (we recommend an old piece of scrap wood.) It is also a good idea to elevate your board off the surface somehow. Whatever surface you place your board on will act as a big heatsink and make it harder to reflow. You could also use a third hand if you have one.



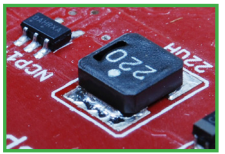
If you want more in-depth information and tips on using your hot-air rework station, check out our How to use a Hot-air Rework Station tutorial online at: http://www.sparkfun.com/reworkstation

4. Start with the tip of the heaterizer above the board about 4-5 inches. Move the hot air nozzle continuously over the board, never stopping in one spot for more than a few seconds. Do this for at least two minutes, or until you see the solder beginning to reflow. Make sure ALL the parts have reflowed. Don't get closer than 1 inch or you will burn your board. **BE CAREFUL OF THE BUZZER**, it can melt!



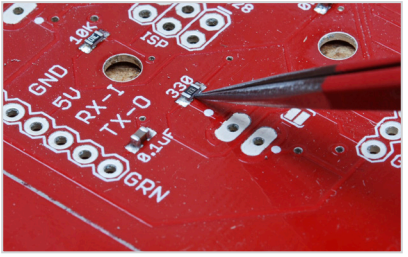
IF YOU SEE BLACK GOO, STOP!!! This means you are applying too much heat. Please see below for examples of reflowed components.

GOOD

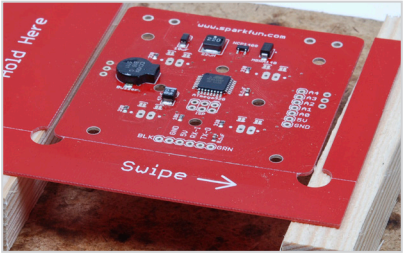


BAD

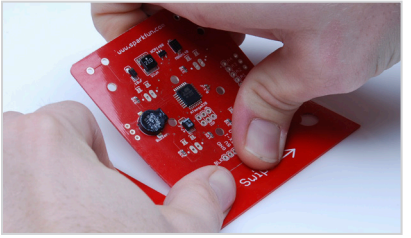
5 Let cool. **DO NOT TOUCH.** To test a component, gently nudge it with your tweezers. If if feels firm, it has reflowed correctly. If it moves around, even a little, you need to apply more heat to it.

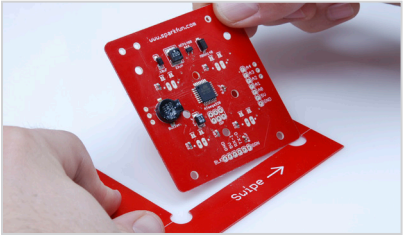


6 Your board should look like the example below.



7 Snap it out of its frame. Don't throw it away though. You can always use it again later.





QUICKSTART • PTH SOLDERING

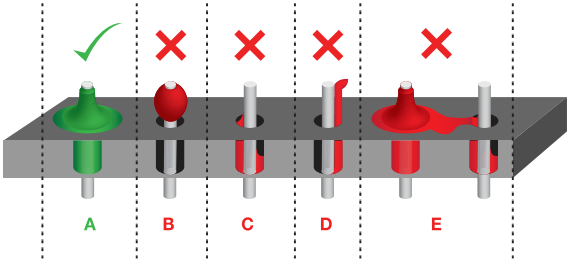
A Solder flows around the leg and fills the hole - forming a volcano-shaped mound of solder.

B Error: Solder balls up on the leg, not connecting the leg to the metal ring.
Solution: Add flux, then touch up with iron.

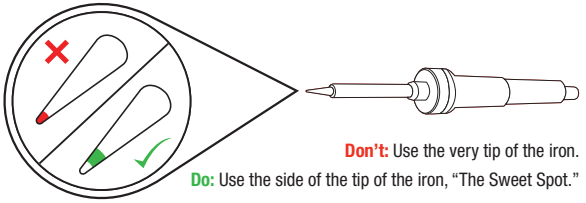
C Error: Bad Connection (i.e. it doesn't look like a volcano)
Solution: Flux then add solder.

D Error: Bad Connection...and ugly...oh so ugly.
Solution: Flux then add solder.

E Error: Too much solder connecting adjacent legs (aka a solder jumper).
Solution: Wick off excess solder.



PTH SOLDERING TIPS



Don't: Use the very tip of the iron.
Do: Use the side of the tip of the iron, "The Sweet Spot."

Do: Touch the iron to the component leg and metal ring at the same time.

Do: While continuing to hold the iron in contact with the leg and metal ring, feed solder into the joint.

Don't: Glob the solder straight onto the iron and try to apply the solder with the iron.

Do: Use a sponge to clean your iron whenever black oxidization builds up on the tip.

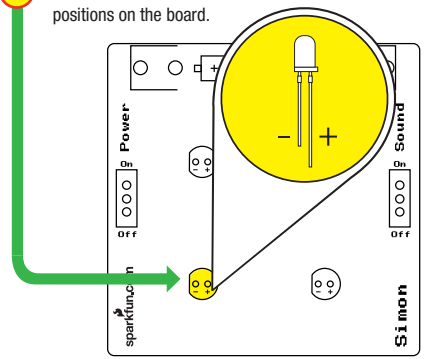
BUILDING THE REST OF THE SIMON: PTH [STEPS 1 TO 16]

Now that you've successfully completed the SMD component section, you can grab your soldering iron and complete the PTH section.

1. Locate the LEDs (qty. 4).

2. Turn the board over and locate one of the LED positions on the board.

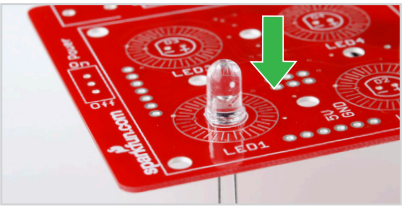
TOP OF BOARD



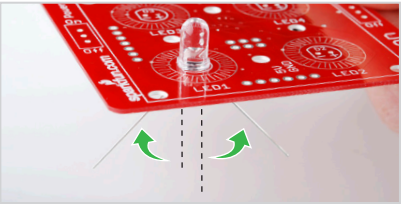
Remember, components highlighted yellow are polarized.

3. Insert the LED into the PCB, so that the short leg goes into the hole labeled with the "-" sign.

4. Push the LED in so it is flush with the board.



5. Slightly bend the legs outward to hold it in place.



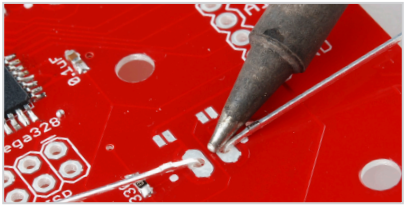
CONTINUE WITH THE **BOTTOM OF THE BOARD**

For step 6 there are four sub-steps.

PRO TIP: The tip of the iron is normally 700°F, hot enough to melt metal. It is normal for the handle of the soldering iron to heat up a bit. Hold it like a pencil and move your hand further away from the tip if the heat is uncomfortable. The solder smokes because the rosin inside the solder is burning off - it's not harmful.

6 Flip the board over. Hold the soldering iron's "Sweet Spot" so it touches both the leg and the metal ring. Hold for 2 seconds.

I



[BOTTOM OF BOARD]

Feed solder into the joint.

II

Pull the solder away.

III

Remove the iron.

IV

7 Your solder joint should look like this - a tiny volcano.

8 Using the same PTH methods, add solder to the second leg.

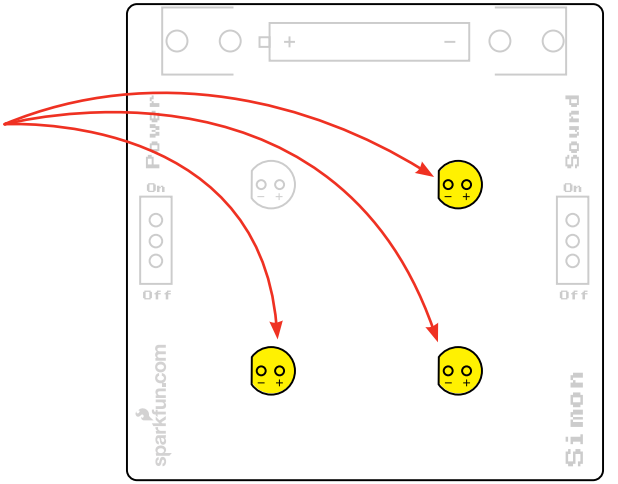
9 Clip off any excess legs.

CONTINUE WITH THE **TOP OF THE BOARD**

[STEPS 10 TO 12]

Now that you've successfully soldered your first PTH component, use the same method to place and solder the next components.

LEDs (indicator lights) Just as you did with the first LED, make sure the short leg goes into the hole labeled "-". Also, make sure it sits flush with the PCB. Then solder into place.



Remember, components highlighted yellow are polarized.

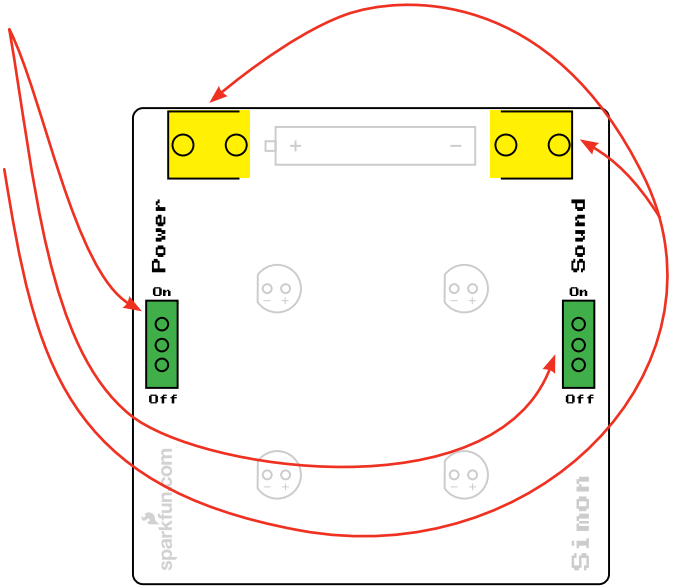
11 Slide Switches

Slide Switches Keep the iron tip away from the black part of the switch! Plastic melts easily (and stinks).

12 Battery Clips ⚠

Battery Clips Both clips need to be pointed towards each other. The solid backing on each clip should face the outside of the board. These require a lot more heat to melt the solder, you need to leave the iron tip on a bit longer than usual (5-6 seconds). Don't touch the clip after soldering! Give it some time to cool off.

TOP OF BOARD



⚠ Remember, components highlighted yellow are polarized.

FINAL ASSEMBLY

[STEPS 13 TO 16]

No screwdriver necessary.
Please only hand-tighten the screws and standoffs.

13 Button Pad

Button Pad (game control) Attach to top. Lay rubber button pad over LEDs.

14 Bezel

Bezel (holds button pad) Attach to top. Lay bezel over button pad, with notches for the screws pointing up.

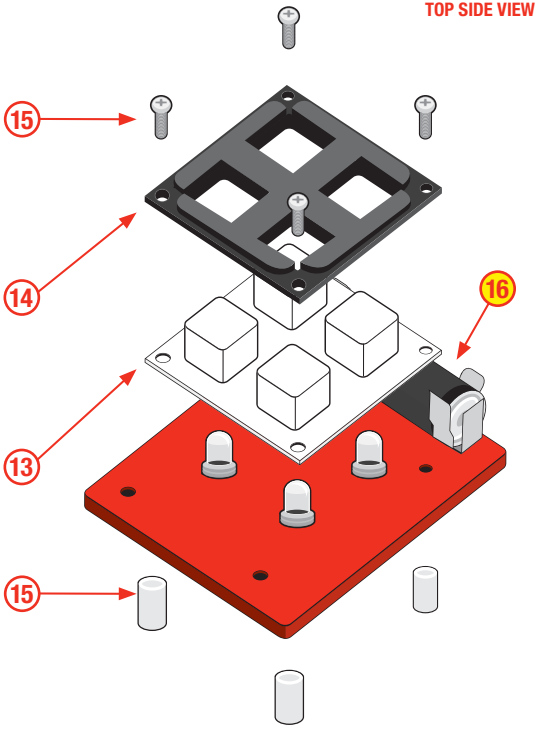
15 Screws x 4

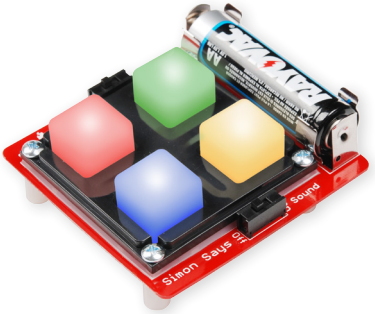
Standoffs and screws (mechanical) Insert the screws through the bezel and button pad, then twist standoffs onto the protruding screw. Hand-tighten.

16 AA Battery ⚠

AA Battery (power source) Insert the battery, following "+" and "-" indicators on the board. Turn on the board and verify the LEDs are flashing.

TOP SIDE VIEW





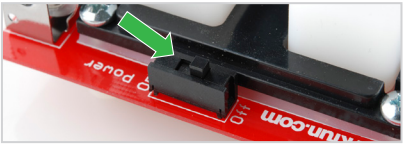
CONGRATULATIONS, YOU'RE DONE!!!

Your Simon game is now completed. Turn it on and have fun! If something is not working (i.e. an LED won't light up), please check out the Troubleshooting sections at the end of this booklet for more help (Pages 44-47).

EXTRA FUN

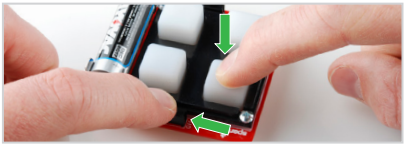
As an example of how the Simon is more than just a game, we have included a special feature in the code. Just for fun, try this out. Don't worry, it won't change your Simon permanently.

1. Turn off power switch.



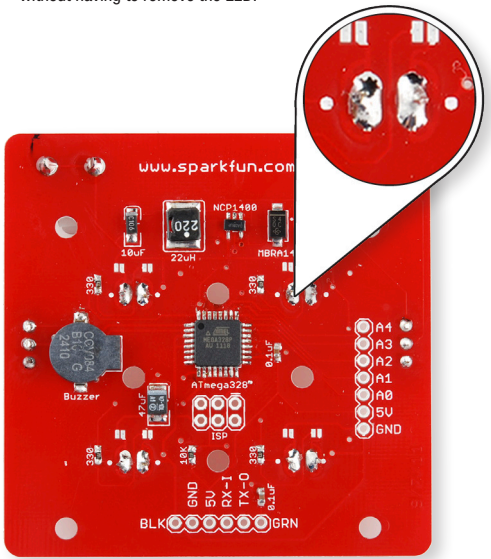
2. Press any one button.

3. While holding button down, turn back on.



TROUBLESHOOTING LEDS

Failing LEDs? Don't fret, there is an easy way to fix it! The most common cause of a failing LED is incorrect polarity. We have designed a special trick into the Simon PCB. You can simply cut the two traces and close two jumpers. This will swap the polarity without having to remove the LED.

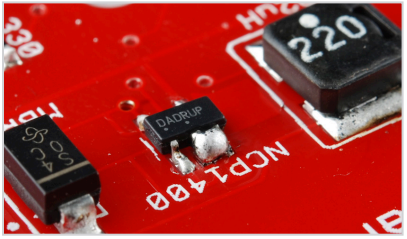


1. Using a hobby knife, cut both traces directly over the white dots.

2. Using a soldering iron, close both jumpers.

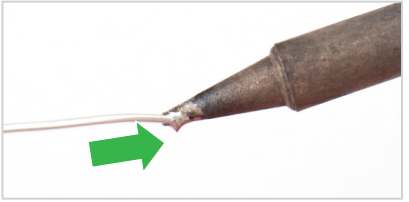
TROUBLESHOOTING JUMPERS

1. If jumpers arise as you're reflowing, don't worry about it! It can be easily fixed.

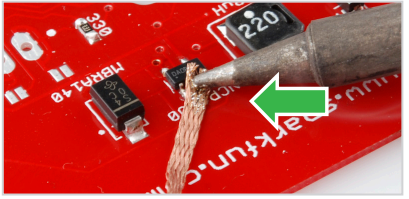


2. Locate a piece of solder wick.

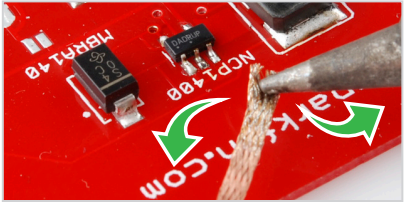
3. Put a small amount of solder on the end of your iron (this will transfer heat from iron to wick to the jumper). Sandwich the wick in between the iron and the solder jumper.



4. Hold still for 2-3 seconds. You will see solder start to flow up the wick.

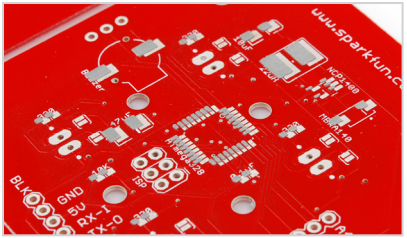


5. Pull both away. Nice and clean!



TROUBLESHOOTING STENCILING

1. If you use too much pressure on your first swipe or the stencil was misaligned, check to see if the solder paste is off-center or smudged.

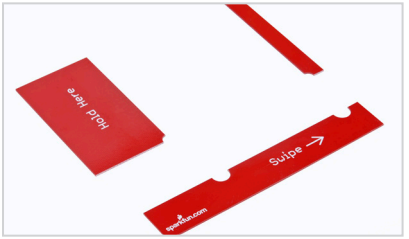


2. With a damp towel, wipe the solder paste off the board. If your board is extra messy from the paste, you can clean it with isopropyl alcohol.

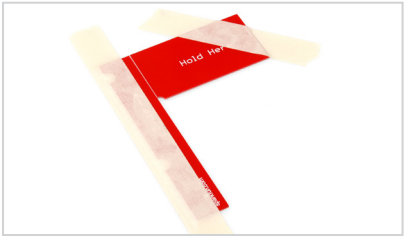
3. With a damp towel, clean the solder paste off the stencil. Now you are ready to go back to the **SETUP** section in this guide.

REUSING THIS KIT WITH THE REGULAR SIMON SMD KIT

1. Locate the three frame pieces.

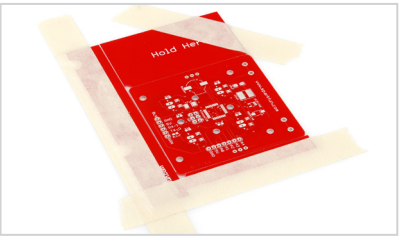


2. Tape together the **HOLD HERE** and **SWIPE** sides.



3. Use the PCB from your regular Simon SMD Kit. Tape down the final frame piece.

4. Now you are ready to reuse the frame from this kit to stencil and paste for the regular Simon SMD Kit!



Glossary of Terms

Buttons, Bezels and Standoffs

Squishy buttons are fun! The bezel helps hold the buttons in place. The standoffs hold the board up off a surface, helping to protect the electronics. They also hold the pad and bezel onto the board.

Buzzer and Other Components

The buzzer makes the noise for the game – pretty simple! The capacitors help "clean up" the power on the board. The resistors limit the current to the LEDs and microcontroller for protection against current spikes. The slide switches turn on and off the power and sound.

Cold Joint

This is similar to a tombstone, except the part may not be sticking straight up, making it harder to see the connection that is not being made.

Flux

Flux is the substance that prevents the beading of solder and helps the solder flow cleanly onto the parts you are soldering.

LEDs

Light-emitting diodes (LEDs) are like light bulbs, but much smaller and more efficient.

Microcontroller

The microcontroller is the brain of the game. It's programmed to light up the buttons and create the game sequence.

Reflow

Reflowing is the process of melting solder paste and turning it into a conductive solder joint, which firmly adheres a component to the PCB.

Rework

Rework is refinishing or repairing an already reflowed board, and is a term commonly used in the electronics world.

SMD

Surface Mount Devices are normally smaller and take up less space than through-hole components. They usually have small, compact leads, but some package types are leadless.

SMT

Surface Mount Technology is the process of assembling and mounting SMD parts onto the surface of a printed circuit board (PCB).

Soldering

Soldering is the process of creating a conductive connection between two metal components. It is done by forming a bond using a filler metal (solder).

Stencil

A stencil is used to mask solder paste onto a PCB, allowing you to save time and effort when assembling and reworking your board.

Tape/Reel

This is the preferred method of packaging small SMD components by manufacturers. SMD components are placed in a plastic enclosure, sealed with tape, and placed in a reel.

Tombstone

This is when a part (usually a resistor or capacitor) reflows only on one side. The part usually sticks straight up, resembling a tombstone.

Notes

CREATE YOUR OWN PROJECT WITH SIMON

Did you know that your Simon is much more than it seems? It can be re-programmed to do many different things! You can write code to change your Simon into a new unique project. To learn more, please check out our online tutorial here: **sparkfun.com/tutorials/203**

And for even more fun stuff go here: learn.sparkfun.com

sparkfun.com