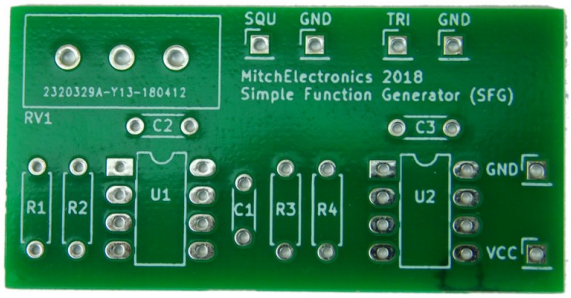
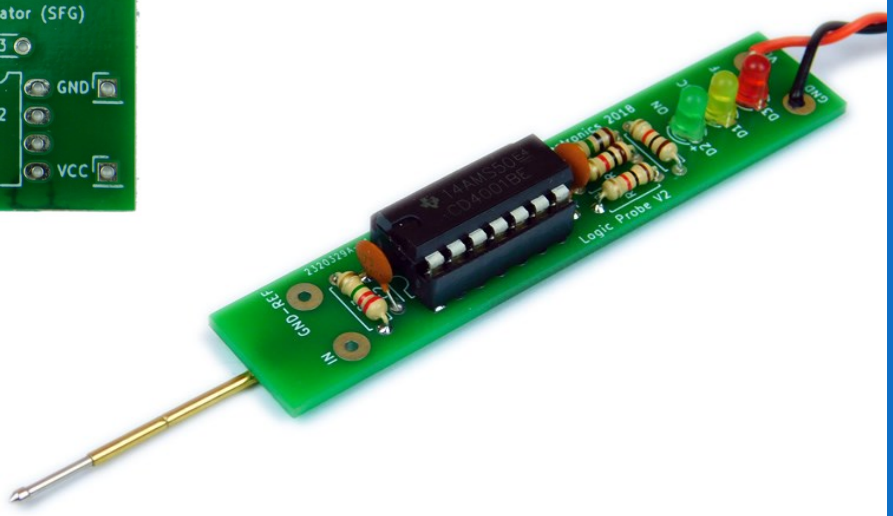
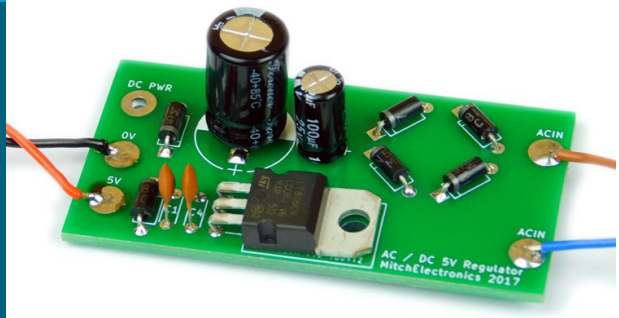
Electronics Construction Manual

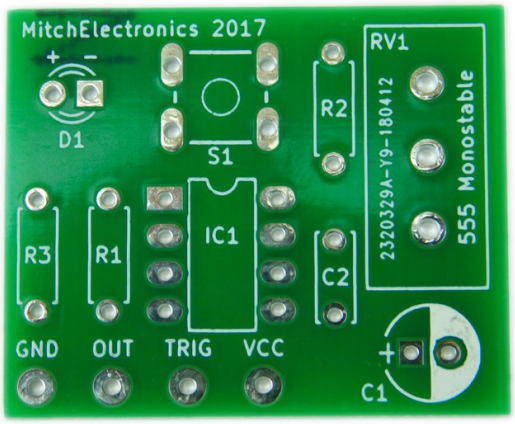
MitchElectronics 2020

Version 4—23/05/2020









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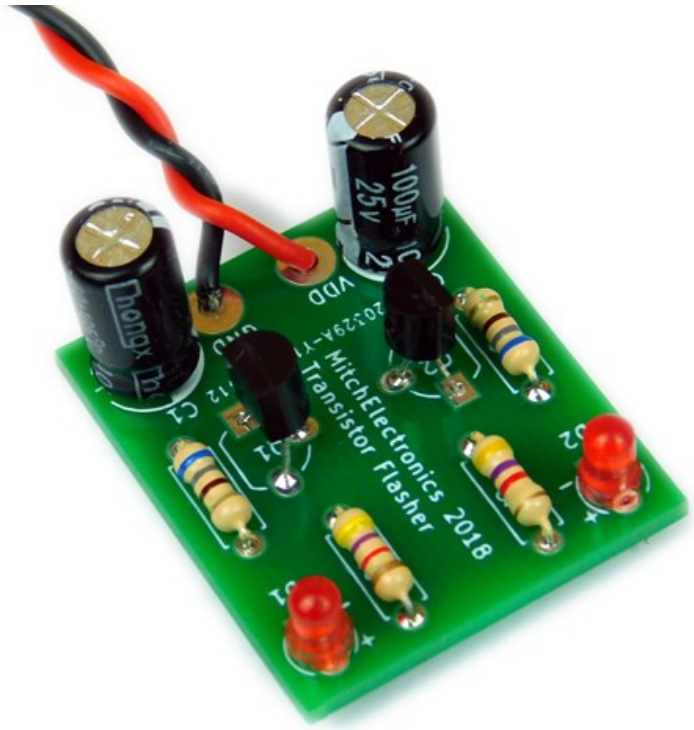
Introduction

Building electronic circuits is not only a fun activity but good for improving dexterity. But the art in building circuits is not just in knowing what part you need to solder but where it goes and what order to put parts in!

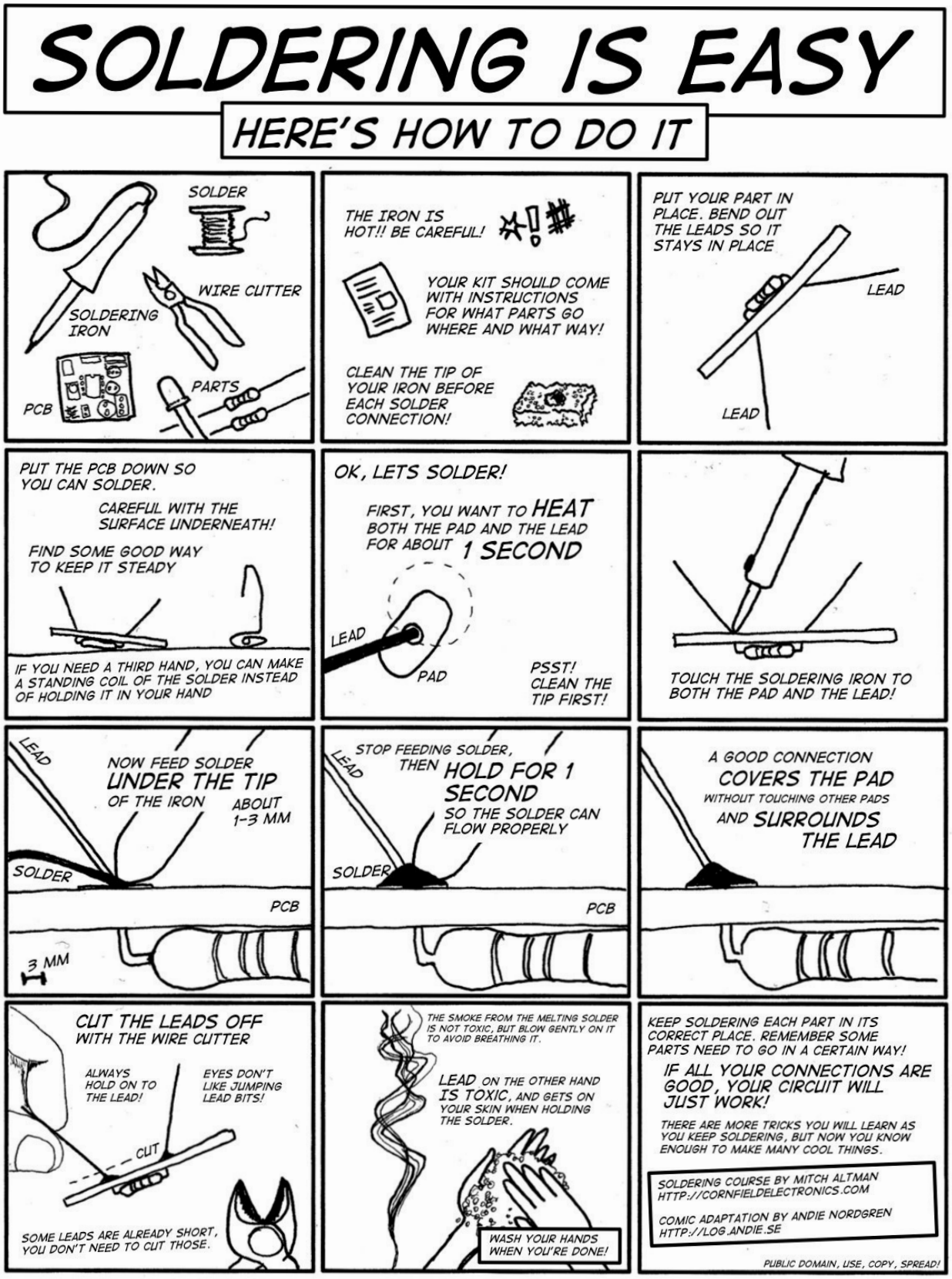


The transistor flasher kit is good for solder practice!

Depending on the kit that you have, you will need to read the relevant chapters in this book so that you know how to put each component in. For example, the 555 astable kit does not have any transistors and so the transistor chapter does not need to be understood. Before continuing make sure you have the following equipment

- Soldering iron, soldering iron stand, wet sponge, and lead-free solder
- Small pliars, screwdrivers, tweezers, and wire cutters

So you have your kit, checked that all the parts are included, and understand which chapters you need to keep an eye on it's time to move onto the next section… how to solder!


SOLDERING IS EASY
HERE'S HOW TO DO IT
SOLDER
WIRE CUTTER
SOLDERING IRON
PCB
PARTS
THE IRON IS HOT!! BE CAREFUL!
YOUR KIT SHOULD COME WITH INSTRUCTIONS FOR WHAT PARTS GO WHERE AND WHAT WAY!
CLEAN THE TIP OF YOUR IRON BEFORE EACH SOLDER CONNECTION!
PUT YOUR PART IN PLACE. BEND OUT THE LEADS SO IT STAYS IN PLACE
LEAD
LEAD
PUT THE PCB DOWN SO YOU CAN SOLDER.
CAREFUL WITH THE SURFACE UNDERNEATH!
FIND SOME GOOD WAY TO KEEP IT STEADY
IF YOU NEED A THIRD HAND, YOU CAN MAKE A STANDING COIL OF THE SOLDER INSTEAD OF HOLDING IT IN YOUR HAND
OK, LETS SOLDER!
FIRST, YOU WANT TO HEAT BOTH THE PAD AND THE LEAD FOR ABOUT 1 SECOND
LEAD
PAD
PSST! CLEAN THE TIP FIRST!
TOUCH THE SOLDERING IRON TO BOTH THE PAD AND THE LEAD!
LEAD
NOW FEED SOLDER UNDER THE TIP OF THE IRON
ABOUT 1-3 MM
SOLDER
PCB
3 MM
STOP FEEDING SOLDER, THEN HOLD FOR 1 SECOND SO THE SOLDER CAN FLOW PROPERLY
LEAD
SOLDER
PCB
A GOOD CONNECTION COVERS THE PAD WITHOUT TOUCHING OTHER PADS AND SURROUNDS THE LEAD
CUT THE LEADS OFF WITH THE WIRE CUTTER
ALWAYS HOLD ON TO THE LEAD!
EYES DON'T LIKE JUMPING LEAD BITS!
CUT
SOME LEADS ARE ALREADY SHORT, YOU DON'T NEED TO CUT THOSE.
THE SMOKE FROM THE MELTING SOLDER IS NOT TOXIC, BUT BLOW GENTLY ON IT TO AVOID BREATHING IT.
LEAD ON THE OTHER HAND IS TOXIC, AND GETS ON YOUR SKIN WHEN HOLDING THE SOLDER.
WASH YOUR HANDS WHEN YOU'RE DONE!
KEEP SOLDERING EACH PART IN ITS CORRECT PLACE. REMEMBER SOME PARTS NEED TO GO IN A CERTAIN WAY!
IF ALL YOUR CONNECTIONS ARE GOOD, YOUR CIRCUIT WILL JUST WORK!
THERE ARE MORE TRICKS YOU WILL LEARN AS YOU KEEP SOLDERING, BUT NOW YOU KNOW ENOUGH TO MAKE MANY COOL THINGS.
SOLDERING COURSE BY MITCH ALTMAN
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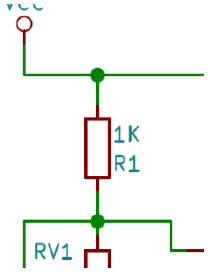
Resistors

The first component that you should solder are resistors as they are some of the smallest components. Resistors are identified with the letter R followed by a number where each resistor has a unique number. The number of the resistor in the schematic is the same as that on the PCB so R1 in the schematic fits into the R1 component on the PCB.

The example below shows R1 in a schematic which has a value of 1KΩ which means on the PCB for that kit, a 1KΩ resistor needs to be inserted into the R1 space shown below.



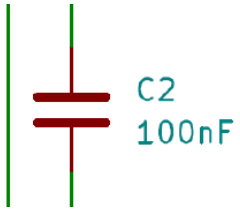
First, push the resistor all the way into the slot so that the resistor is flush with the PCB and the legs are all the way through. Then flip the PCB over, solder each leg of the resistor, and then cut the legs just above the solder joint.

Capacitors

Capacitors come in different varieties with the two main categories being ceramic and electrolyte. Ceramic capacitors are easy to solder but electrolytic capacitors need a bit of care as they are polarized and only fit in a specific orientation.

Ceramic Capacitors

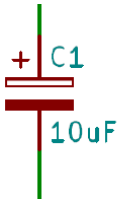
Capacitors are identified with the letter C in both the schematic and the PCB and each capacitor has a unique number. For example, if capacitors C1 in the schematic is a 100nF capacitor then a 100nF capacitor needs to be soldered to the C1 component space on the PCB. To solder a ceramic capacitor, place the ceramic capacitor into the capacitor slot



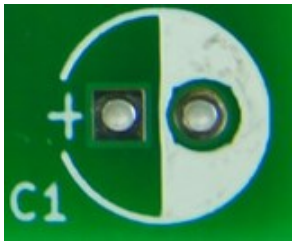
and push down until the capacitor is a few mm from the PCB (do not push in all the way). Then solder the legs on the underside of the PCB and trim off the excess legs.

Electrolytic Capacitors

Electrolytic capacitors are also identified with the letter C but they must be inserted in a specific way as they are polarized (have a + and - leg). The positive leg of the capacitor is longer than the negative leg and if the legs are the same length then the negative leg can be identified by looking for the leg next to the negative stirp on the side of the capacitor.

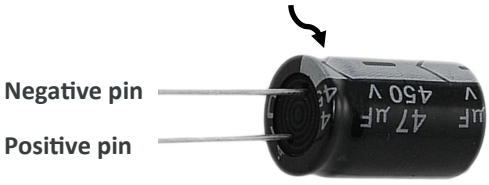


Electrolytic capacitors look like this on schematics



The square pad is the positive pin!

Can you see the negative strip on the side?

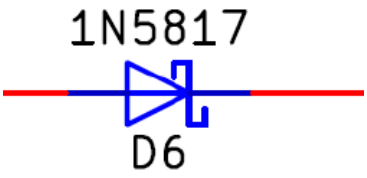


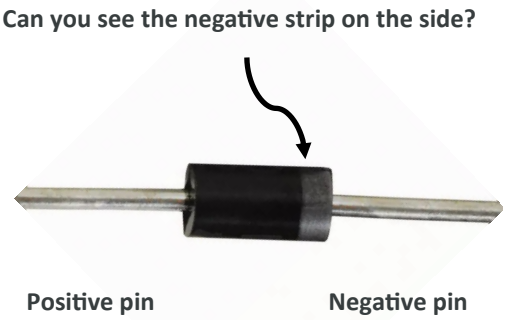
Diodes and LEDs

Diodes and LEDs are both polarized components and therefore MUST be inserted in the correct way otherwise they will not work! Both components are identified with the symbol D but on rare occasions LEDs may also have the identification of “LED”. As with all other components, each diode and LED has a unique number that links the schematic and PCB component position together.

Diodes

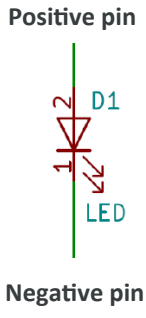
Diodes have a band on the outside of the component and this band sits close to one of the legs. The leg that is closest to the band is the cathode (the negative pin), while the leg furthest away is the anode (positive pin). The schematic symbol for a diode shows an arrow with a line where the line represents the cathode and the PCB symbol is similar to the diode itself.

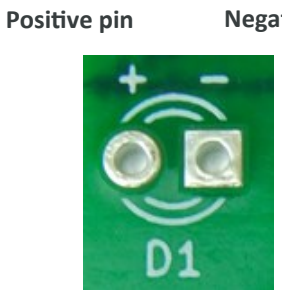




LEDs

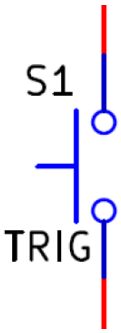
LEDs are identified with the diode symbol that has arrows pointing away while the PCB symbol is not entirely obvious. The square pad on the PCB is the cathode while the round pad is the anode. The longer lead of an LED is the anode while the shorter lead is the cathode and it is important that these leads are not cut until the LED is soldered in place!



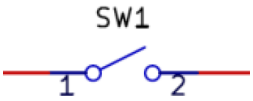


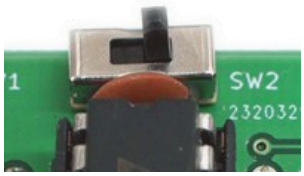
Switches

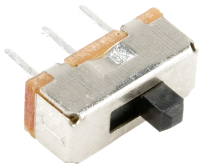
Switches are easy components to solder and are identified with the letter S but may also be called SW followed by a unique number. Tactile switches have dents in their legs which create a “click” sound when the switch is fully inserted into the PCB (this is how you will know that the component is sitting flush with the PCB).



While tactile switches are useful for momentary action (such as a push to roll on a dice) other switches are useful for turning off or on power. These types of switches are identified with a different symbol (shown below) and have component identifications SW and S.



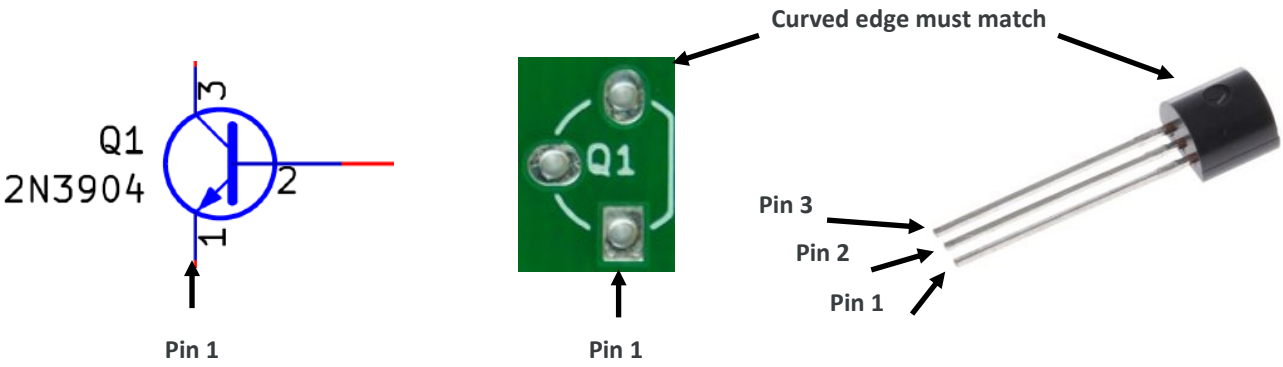




Transistors

Transistors are one of the harder parts to solder due to their sensitivity to heat, their three pins, and that they have a specific orientation which means you need to make sure that they are placed in the correct way.

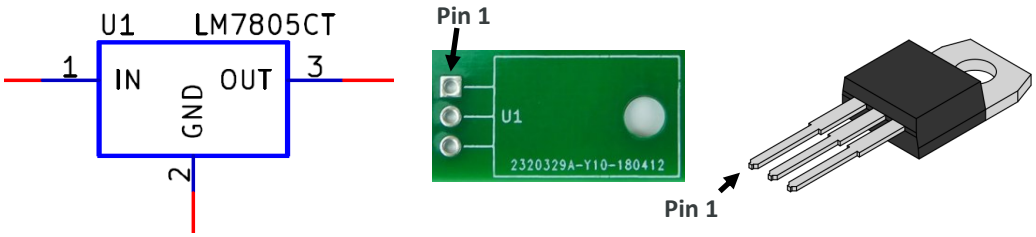
Transistors are identified with the letter Q followed by unique number and the identification in the schematic is identical to that found on the PCB. Transistors come in many different shapes and sizes but unless stated otherwise all transistors used in MitchElectronics kits are in the TO-92 package.



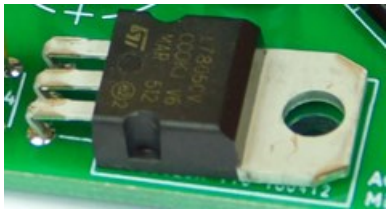
When soldering transistors it is important to place a crocodile clip across the legs as this will help to keep heat away from the transistor. If you can solder quickly (less than 5 seconds per pad), then you do not need to use a heatsink but if you are not confident with an iron then a heatsink could go along way.

Regulators

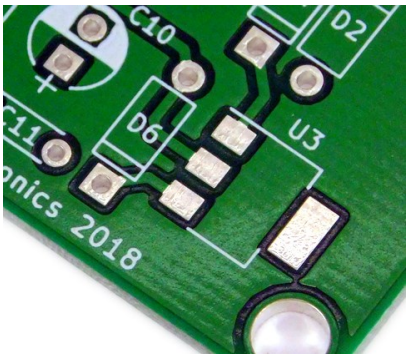
Regulators come in all shapes and sizes but the main three ones used in MitchElectronics kits are the TO-220 package, the TO-92 package, and the SO-223 surface mount package. Regulators are ICs and therefore have the identification of either U or IC followed by a unique number.

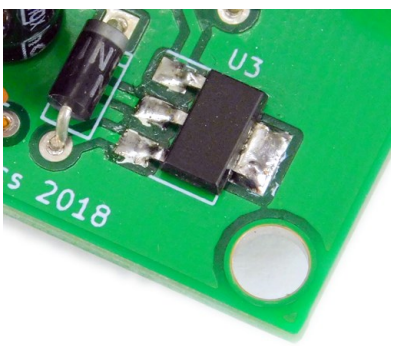


Soldering TO-92 regulators should be done in the same way as transistors but soldering TO-220 parts is easier. One of the reasons for this is because TO-220 packages are designed to handle heat dissipation so soldering their legs should not cause heat issues. Place the part into the correct holes and then bend the part so that it sits flush with the PCB. A small bolt can be used to keep the part from raising but this is not too important for MitchElectronics kits.



Some regulators are of the surface mount kind (mainly the AMS1117 3.3V regulator) which are soldered directly to the top side of the PCB. Soldering these can be tricky and require some care so the first step is to apply some solder to the large tab first and with a pair of tweezers hold the regulator over the pads and then heat the tab up. Once the part is secure with the tab soldered proceed to soldering the three other small legs.

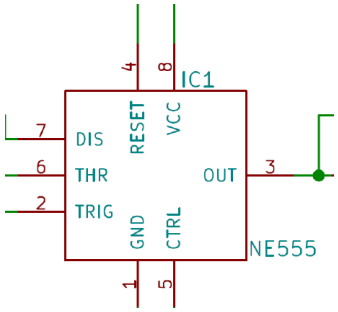


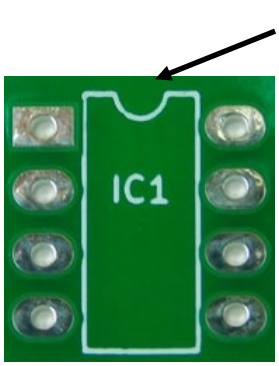


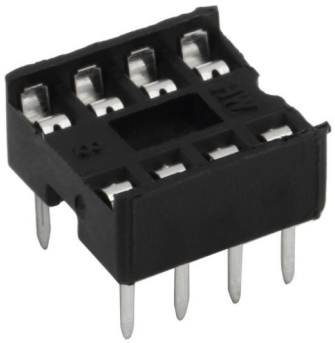
Integrated Circuits

Integrated circuits are easy to solder when using IC sockets. IC sockets are parts that look like ICs but are just a pair of connector rows that allow ICs to be inserted into after soldering. The reason why they are used instead of soldering ICs directly to the PCB is because ICs are very sensitive to static electricity and heat so it is best to put ICs into sockets. ICs on schematics and PCBs are identified with the letter U or IC followed by a unique number.

When soldering the IC socket to the PCB make sure that it is fully inserted and that it is facing the correct orientation. The socket has a small circular notch at the front and this should line up with the notch on the PCB. With the IC socket fully inserted flip the PCB and solder the top left pin and the bottom right pin. Then look at the socket to see if the socket has been soldered in correctly. If it has then solder the rest of the legs otherwise re-solder the two pins and adjust the socket as needed.



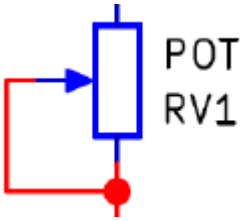


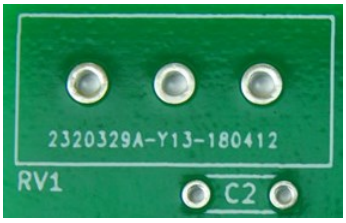


Once the circuit has been COMPLETELY built the ICs can then be inserted into their respective sockets. Make sure that the notch in the IC matches the notch in the socket which matches the notch on the PCB.

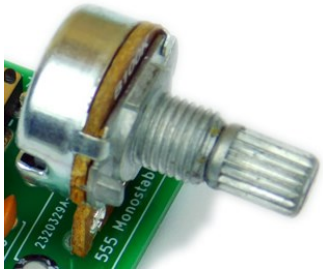
Potentiometers

Potentiometers are some of the harder parts to solder as they are usually big and bulky. Potentiometers are identified wit the word RV followed by a unique number that is the same on the schematic and the PCB. When inserting a potentiometer the orientation matters not because the part wont work but because they have adjustment knobs which may be hard to turn if they are facing a different direction.





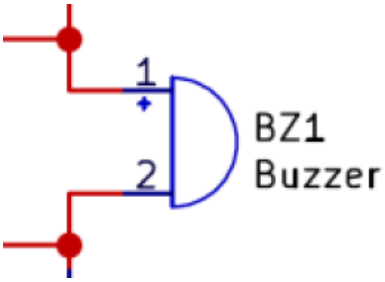
Soldering a potentiometer can be a slight challenge but the best approach is to leave the components till last, insert them, flip the PCB, and then keep the board resting on the potentiometer as you solder it. If you still struggle to solder it in then insert the potentiometer and the solder the top side instead!

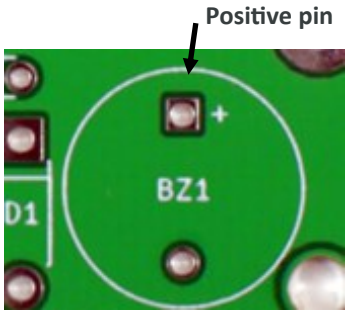


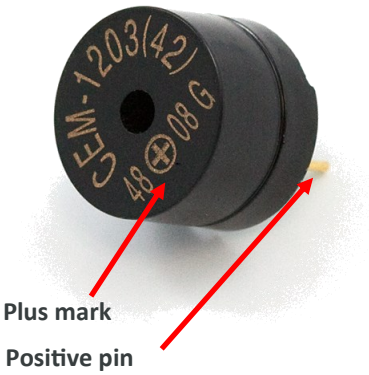
Some potentiometers are much smaller for space and weight saving. These are sometimes referred to trim potentiometers and are found on many MitchElectronics kits. They are easy to identify and insert as they can only be placed in one orientation.

Buzzers

Buzzers are typically identified with the identification of BZ followed by a number however, most circuits only have one buzzer and so only BZ1 will be found. Buzzers are large components that should be one of the last components soldered and are easily identifiable with a large circle and two pad. Buzzers are polarised parts which mean they MUST be inserted the correct way (like electrolytic capacitors and LEDs). The positive lead on a buzzer can be identified in two different ways. The first, and most easiest, is to identify the longest lead as this will be the positive lead. The second method involves looking for a small plus mark on the top of the buzzer and this mark is directly above the positive lead.



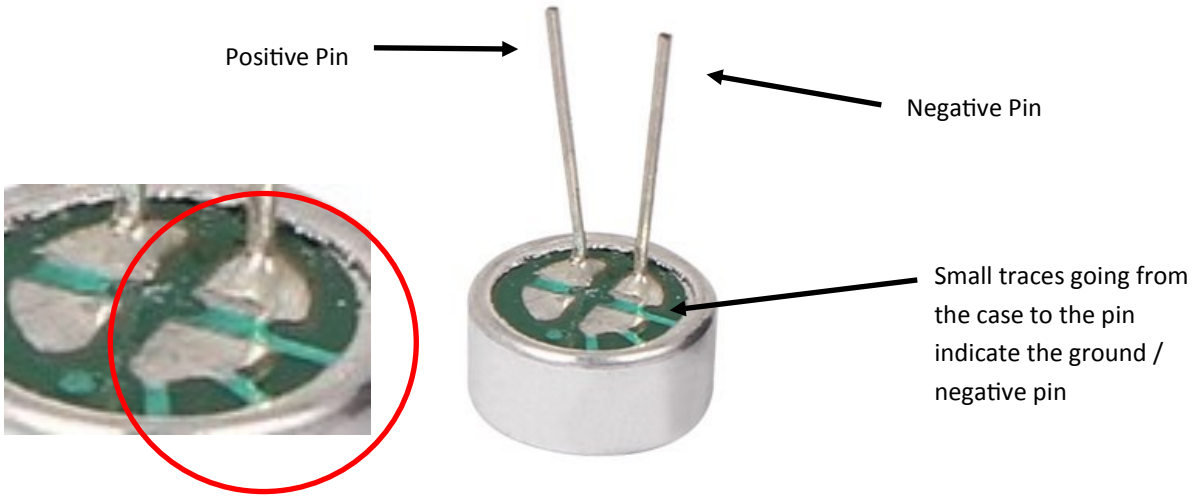


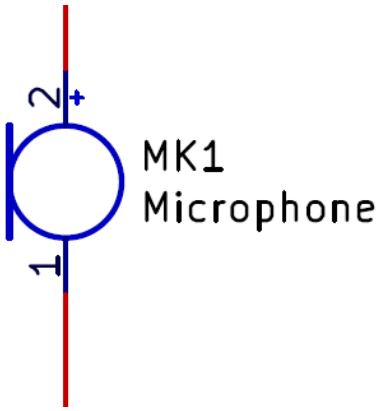


Some buzzers, like the one found in the continuity probe kit, are not polarised and are instead passive. These can be identified as they are wider than the magnetic buzzer, are lighter, and have equal length pins.

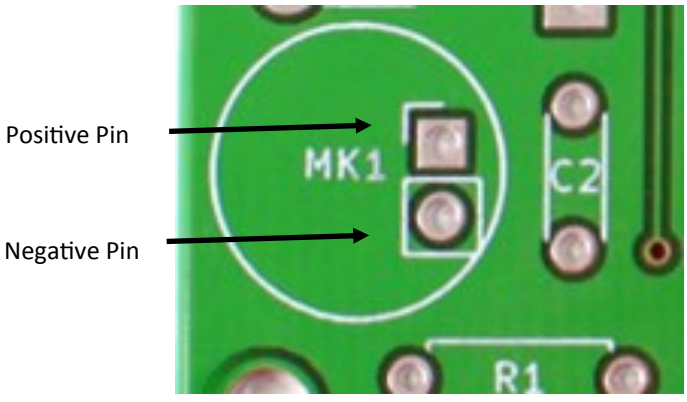
Microphones

All microphones used in MitchElectronics kits are of the electret type, which means that they have a polarity. Therefore, it is imperative that they are inserted the correct way for them to function correctly as well as prevent damage. Unlike LEDs and polarised capacitors, electret microphones have legs that are both of equal length, making the identification of the positive lead difficult. The only way to identify the positive lead on an electret microphone is to look at the underside of the microphone and see which leg has small electrical wires going towards the metal base. The leg that has these small connections is the negative pin, and the other is the positive pin. Electret microphones are often identified with the PCB symbol MK followed by a number, and the positive lead is identified with the square pad.





Schematic drawing of a microphone

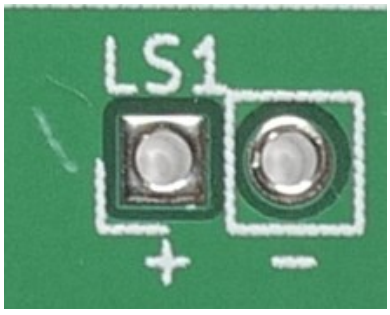


Microphone connector on a PCB

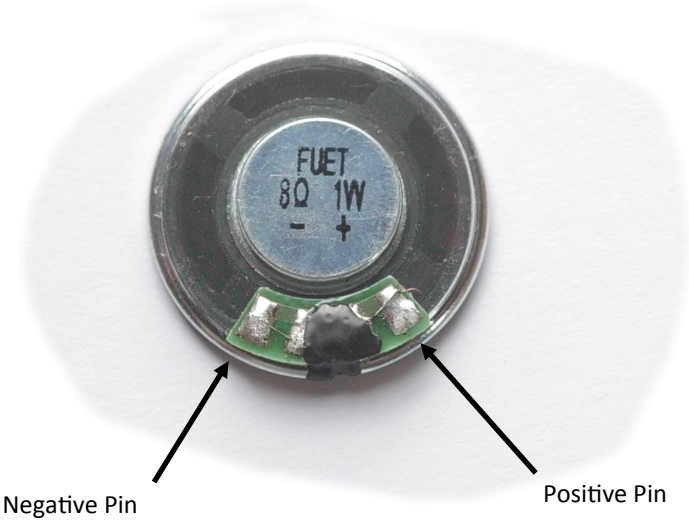
Speakers

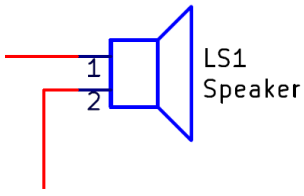
Speakers are an interesting component as they technically have a polarity which is marked by a + and - on the speaker itself. However, the polarity is only important in crucial acoustic applications as the polarity indicates which way the speaker will deflect when power is applied. If two speakers are used in a sound system, their polarities must be identical; otherwise, the two speakers will cancel each other out (see wave interference patterns). For simple kits that only have one speaker, the polarity does not matter.

Most, if not all speakers, have two sets of solder contacts and it is important that the correct one is used. If you look closely at the speaker, two contacts have tiny wires connecting to them as well as a small smudge of black epoxy; this is the contact that you want to LEAVE ALONE! These wires are what connect the external solder pads to the coil inside the speaker. The picture below shows which solder connections you must use when attaching wires to the speaker.

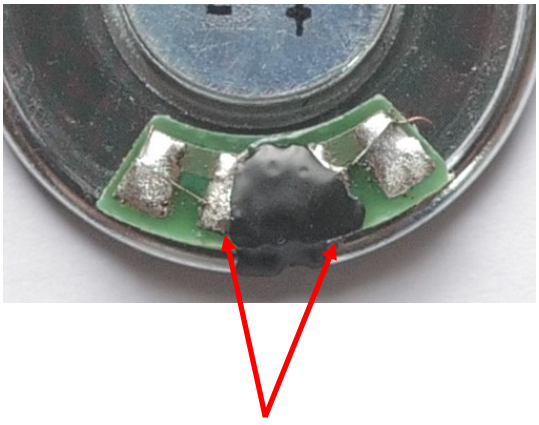


Speaker connector on a PCB





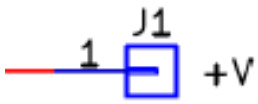
Schematic drawing of a speaker



DON'T solder to these pins

Wires

Wires are used to connect the circuit to either power, input signals, or output signals. Wires do not have a specific identification but are often connected to ports which are typically identified as either P or J followed by a unique number. The colour of wires does not make a difference to the functionality of the circuit but they can help identify what they do.



Wires that are used to power the circuit should be red and black where red wires should connect to VDD and VCC while black wires should connect to GND, VSS, and 0V.