WORKSHOP DIY_101

Assembly Guide

Worksheets and Kits Provided by:

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WARNING

REPLACE WITH SAME BATTERY TYPE

USE ONLY 9V POWER SOURCE

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DIY_101

Today we are going to learn about the theory and skills required to get started building your own DIY analog audio electronics and to pass those skill onto others

Audio electronics is a relatively simple branch of electronics (honestly!). Once you learn a few basic skills (such as soldering), become familiar with the electronic components involved, and learn to read basic schematics, you will be in a position to begin creating truly uniques instruments, start modifying your existing gear, and be able to make repairs.

SAFETY FIRST !

Throughout the day we will be using soldering irons. These are used to melt a soft metal with a low melting temperature, to bind other bits of metal together. It's bit like metal glue.

The soldering Irons get extremely hot and will burn you if you touch them below the plastic handle.

-Always leave the iron in its holder when you are not using it

-Never leave it o the table or you may burn yourself or a friend.

-The metal holder for the iron gets hot too, so be careful not to touch it.

-Always wear your safety goggles (Even when you are not soldering).

-Wash your hands after soldering with soapy water!

WHAT IS ELECTRICITY?

ELECTRICITY IS THE FLOW OF ELECTRICAL CHARGE THROUGH A CONDUCTOR, FROM A HIGH VOLTAGE TO LOW VOLTAGE

WHAT DOES THAT MEAN?

Electrical charge comes from electrons. Electrons are tiny particles that are free to move in conductors, such as metal, graphite and any solution with salt desolved in it (like blood!). The opposite of a conductor is an insulator. Examples of an insulator include plastic, rubber and glass. Electrons cannot move through an insulator because the electrons are trapped in place in an insulator.

The amount of charge that flows through a point in a conductor over time is known as current.

For the charge to flow we need a difference in voltage. We can get voltage differences in batteries and from the wall sockets. Never put anything into a wall socket that isn't a plug- it is very dangerous. Small batteries, like the ones you find in your toys and remote controls are safe to handle, and that's what we will be using today for our project.

As current flows through our conductor, th electrons often crash into the atoms in the material, creating heat. These collisions cause resistance to the flow of the current in the conductor.

So there are three basic elements to the science of electricity:

The current (I) - measured in Amps (A)
The Voltage (V) - measured in Volts (V)
The Resistance (R) - measured in Ohms (Ω)

These are related in a famous equation, called Ohm's Law, which goes like this:

Current (I) = Voltage(v)/Resistance(R)

This equation is telling us that the current that flows through a conductor, equals the voltage between either end of the conductor, divided by the conductor's resistance.

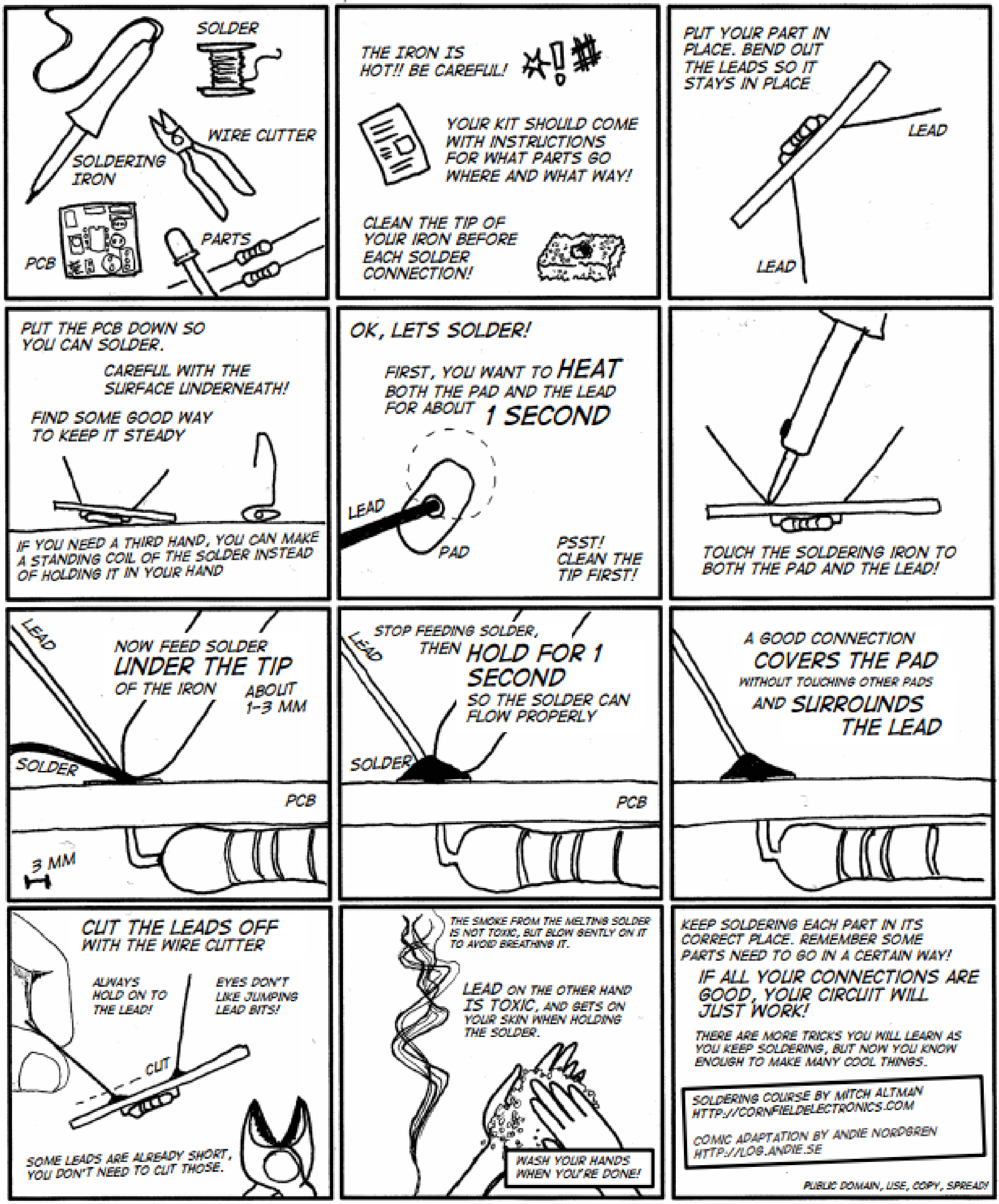
TYPES OF CURRENT FLOW IN CIRCUIT

There are two common types of current flow you will come across in electronics. These two types are known as: DC (direct current) and AC (alternating current).

Direct current (DC) is the type of current flow you get when you use a battery. The battery is at fixed voltage, ad current flows in one direction. Imagine it like water slowly leaking out of a barrel.

Alternating current (AC) is different in that the current is under the influence of a changing voltage. Often between states of positive and negative voltage. This makes the charge move back and forth within the circuit. You can imagine this like water sloshing back and forth within a container. AC is the type of current flow in the signal carrying cable in your headphones.

SOLDERING IS EASY; HERE'S HOW TO DO IT



SOLDERING

HELPING HANDS

To make life easier for us, we can use "helping hands" to hold our board and components in place. The helping hands consists of metal limbs with crocodile clips at the end. The joints at the corner of each limb are adjustable by loosening and tightening their screws. Take a bit of time to adjust these to make your soldering experience as comfortable as possible.

The helping hands also contains the soldering iron stand. Just be careful not to burn yourself!

SOLDERING!

We are now going to learn some useful soldering skill.

1. Solder a wire to the board. Begin by pushing the wire through the back of the board (the plastic side) and solder onto the metal side. *Use the helping hands to hold both the wire and the board in place, and make sure the wire is sticking through the board at right angles to its surface.*

2. Solder a second resistor onto the board. Put the resistor through the back of the board (the plastic side) and solder onto the metal side. *Leave enough of a gap between the legs of the resistor so that the body of the resistor can lie flat. Once it's in place bend one of the legs to hold it still*

3. Solder a second resistor onto the board. This time solder it into two holes that are side by side. *You will need to bed one of the legs so that it is parallel to the body of the resistor and the other leg. This will allow the resistor to sit up o the surface of the board.*

4. Sometimes you need to solder wires together, or solder a wire to the leg of a component. To do this we first need to add a bit of solder to each bit of wire we are going to solder together. This is called 'Tining' the wire.

Put the wire in the helping hands, heat one end of the wire with the soldering iron, then press the solder against the end of the soldering iron. You will see the solder flow onto the wire. Now repeat with the second wire

To finish, leave the second wire in the helping hands, take the iron in your writing hand, and the other wire in your other hand. Bring the wires together and use the iron to melt the solder. With a steady hand move the

MAKING THE INSTRUMENT CABLE

To connect different bits of equipment we need cables that will carry the electrical signal between them. This is what we are going to make now.

This cable is made up of a single core wire with a 'shield' of braided copper wire, and connectors on each end.

THE WIRE

The wire is made up of four parts:
-2 inner conducting parts:

The inner conductor (copper wire) that carries the signal, and an outer conductor (copper braid) that screens the current from interference and connects the ground (zero volts) between devices.

-2 insulating parts:

The outer insulation and the insulation between the inner conductor and the copper mesh.

THE CONNECTORS

There are two parts to the connectors. The metal "Jack" that connects the different equipment, ad its insulating cover.
We need to first put both insulating covers over the ends of the wire, with the large open side facing each end.

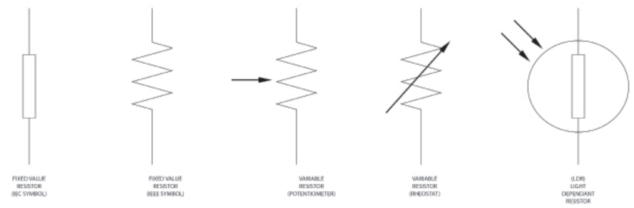
SOLDERING THE CABLE TOGETHER

We have to solder the connectors to either end of the wire. The conducting copper wire from the middle of the wire goes through the hole at point A in our diagram (see below). place the wire through and solder here. The outer conductor goes through point b. Place the wire through and solder into place. Finish by using pliers to squeeze the tabs at the back of the connector jack around the back wire, and screwing over the insulating cover.

COMPONENTS

COMMON COMPONENTS USED IN AUDIO ELECTRONICS

You have already met some of the components that are important in audio electronics. Here are some more common components you will be seeing later today (and hopefully in your electronics career!).



RESISTORS

All components that conduct electricity have some resistance. These fellas are designed to have a very specific resistance so we can control (by reducting) how much charge flows through different parts of a circuit. Resistors are measured in Ohms (Ω).

Uses:
-Current limiting

-Voltage divider

-Set gain levels

-Feedback

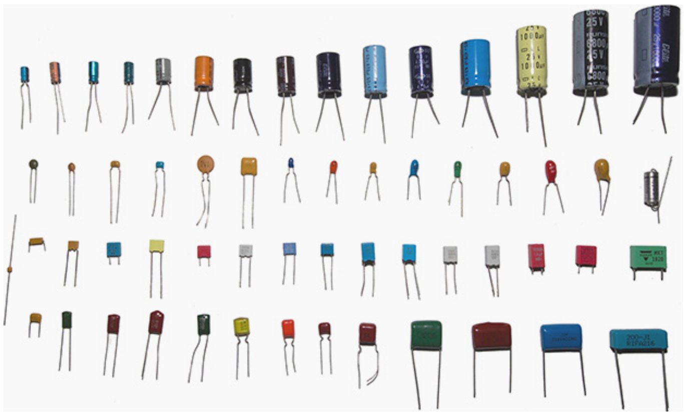
CAPACITOR

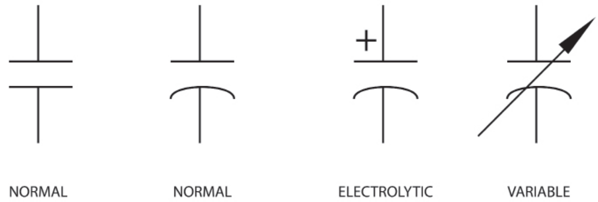
Capacitors are interesting because they can store charge inside them (like a bucket holding water).

They also treat DC and AC in different ways such that they don't let the DC pass through them, but let AC signals pass through them. However, a capacitor will tend to filter out low frequencies of an AC signal. The larger the capacitor the more 'low-end' will pass through. This said however, capacitors are often combined with resistors, inductors and op-amps (amplifier chips) in certain arrangements that manipulate this behavior, so observing a capacitor i a circuit does not directly mean you are dealing with a high-pass filter.

Large 'Electrolytic" capacitors (>1uF) are 'polarised' (they have a positive side and a negative side) and most smaller capacitors are not. The negative is the side with the short leg.

Uses
-Filtering
-Block DC
-Coupling/Decoupling





CAPACITORS ARE MEASURED IN FARADS (F). MOST OFTEN YOU WILL SEE CAPACITORS MEASURED IN MICROFARADS (UF)

DIODE

Diodes are very interesting. They are made fro semiconducting materials, which means that they can conduct current, but only under certain conditions. This means sometimes they act as conductors and sometimes insulators.

Two very interesting properties of diodes are that 1)they only let current flow through them in one direction and 2) current can only flow when the voltage across it is large enough.

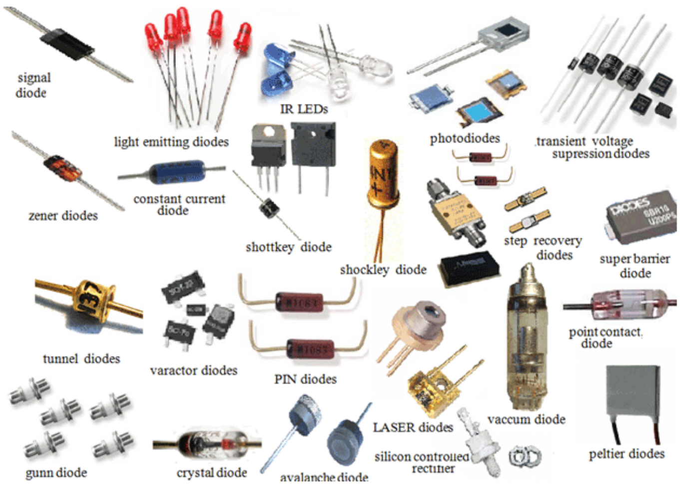
The most common diode, which you may be familiar with, is the Light Emitting Diode (LED). Diodes have a positive side (Anode) and a negative side(Cathode). Most diodes (not LED's) have a black or gray band to indicate the cathode. A common mistake when starting out in DIY audio electronics is to put the diode the wrong way round. Be extra careful with diodes when placing them onto the circuit board (to avoid much heartache)

Uses:
- Convert AC signal to DC

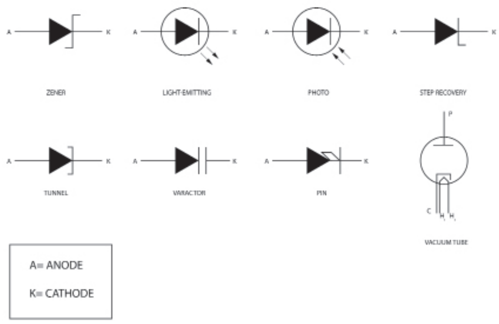
- Voltage Limiting

- Clipping

- Reverse Polarity Protection



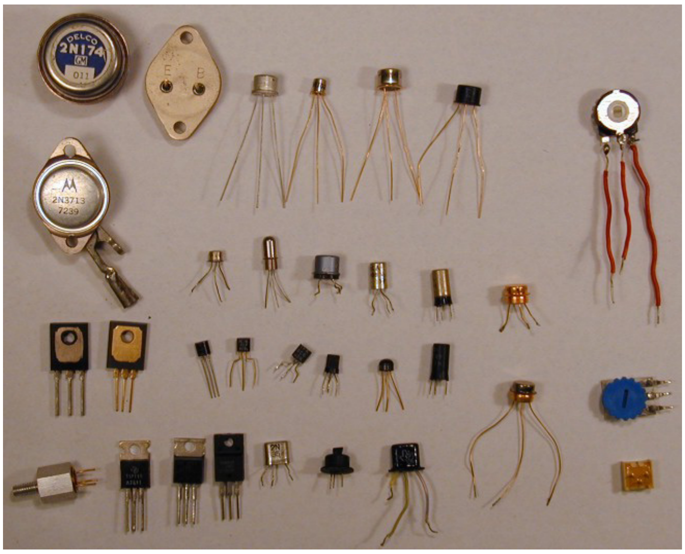
Types of Diode

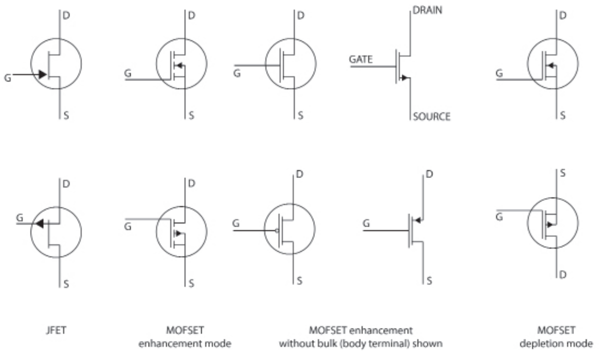


TRANSISTOR

This is also made from semicondulcting materials. The transistor's talent is that it can take a small current and make a large current from it. It acts like a simple amplifier. It can also be used as a switch to turn parts of a circuit on and off.

Transistors come in number of different types. Most commonly we have Bipolar (NPN/PNP) or Field-effect (MOFSET). They work slightly differently, but effectively do the same job.
An important Characteristic of transistors is their gain (how much it amplifies a signal). This can be found from transistor's 'Datasheet' and is marked h or ß.





INTEGRATED CIRCUITS (IC)

These components are made up from the individual (discrete) components previously mentioned, that have been shrunk down to the micrometer level, and arranged into small circuits. Each one is designed to do a different job. You can access different parts of the circuit inside the IC by connecting metal legs.

The standard 'alien bug like' IC package is known as Dual In-Line (DIL). You can also get smaller, surface mount versions called Single In-Line (SIL). These have very short legs and are quite difficult to solder. They are often machine soldered to circuit boards.

There will be a notch cut out of one end of the chip. Moving clockwise fro that point will identify leg one on the chip. Continue clockwise to count through the legs.

Each chip will have an identifying code on its surface to tell you the type of IC it is, and its manufacturer.
To identify what each leg is responsible for and how it should be used, look for the chips 'Datasheet' online.

Examples of types of IC include:
- Opam/Amplifier (Analog)

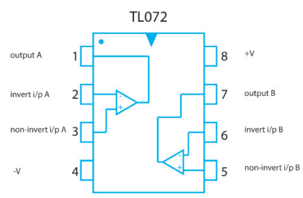
- Timer (Analog)

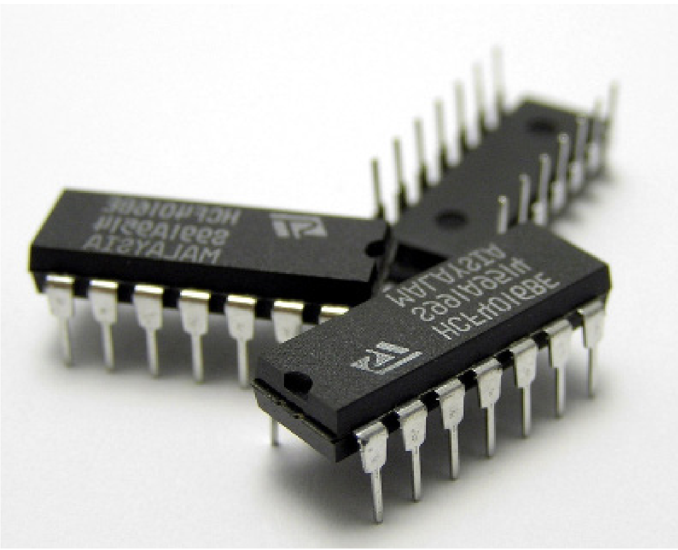
- Decade Counter (Analog)

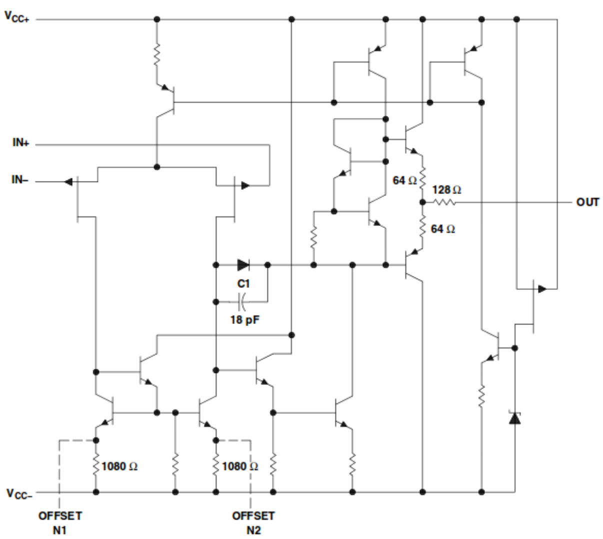
- Voltage Regulator (Analog)

- Logic (Digital)

- Delay (Digital or Analog)

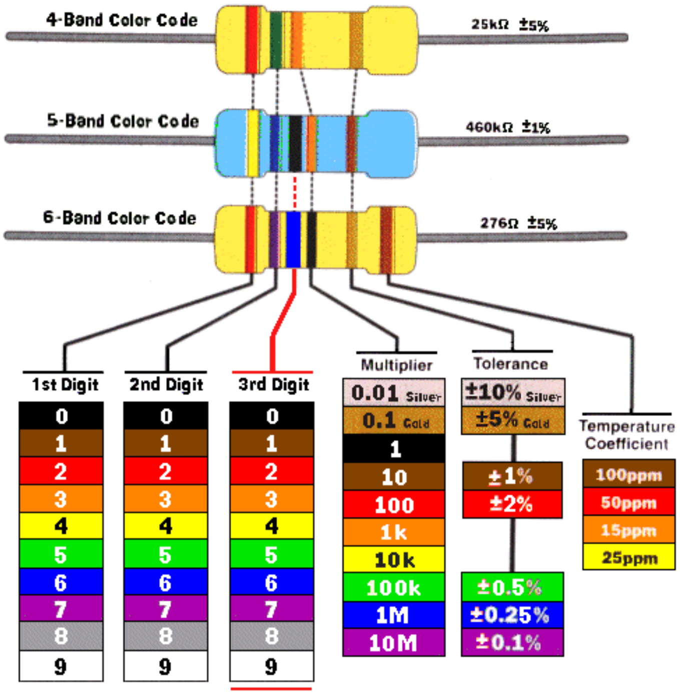






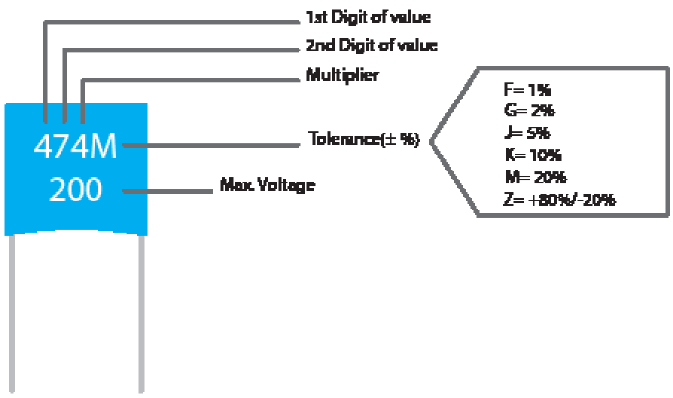
The circuit inside the TL072 IC

RESISTORS NAMING CHART



CAPACITORS NAMING GUIDE

THE RESULT OF CAPACITOR CODE IS GIVEN IN pF



On some capacitors the value is shown as a straight number(4.7pF). On others the decimal point is replaced with the first letter of the prefix (4p7 = 4.7pF)

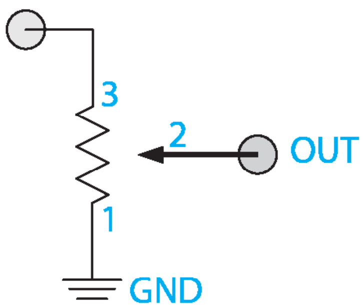
Prefix	Abbr.	Multiplier
Pico	p	10^{-12}
Nano	n	10^{-9}
Micro	μ	10^{-6}

1000 pico = 1 nano
1 nano = .001 micro
1000 nano= 1 micro

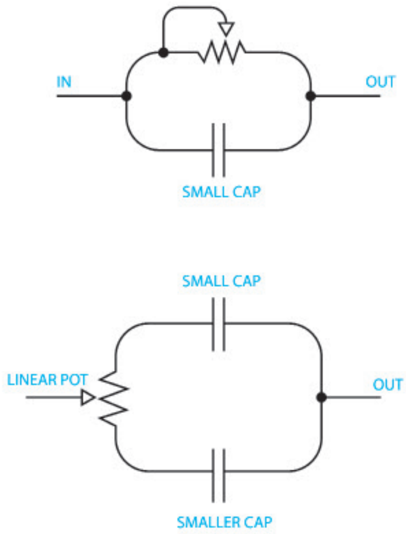
EXAMPLES:
223J = 22 x 10^3pF = 22nF = 0.022μF 5%
151K = 15 x 10^1pF = 150pF 10%

SCHEMATIC EXAMPLES

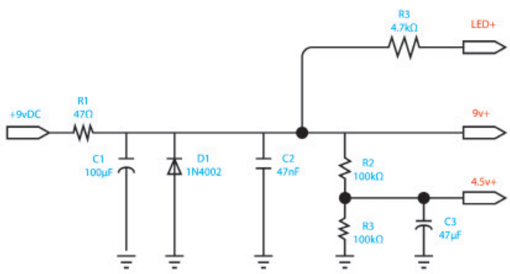
1- Using a potentiometer for volume control



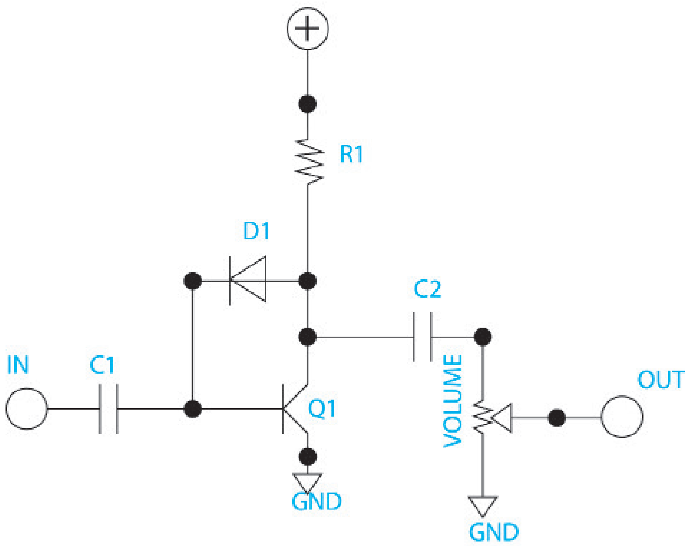
2- Ways of creating an artificial variable capacitor



3- Diode being used for reverse polarity protection



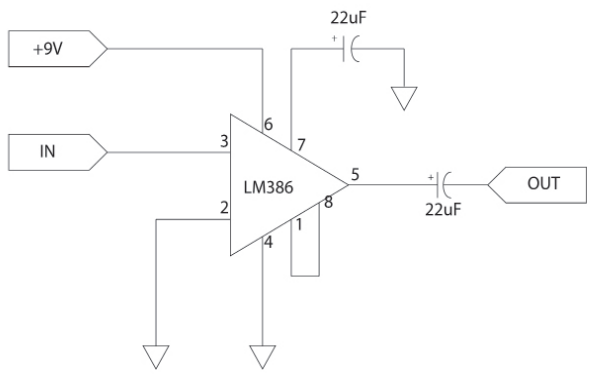
4- 'Bazz Fuss" fuzz circuit, using a transistor and diode to create harmonic rich distortion



SCHEMATIC TO BREADBOARD

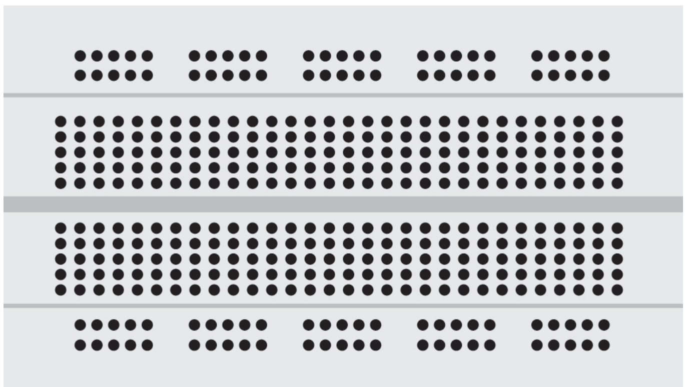
THE AMPLIFIER SCHEMATIC

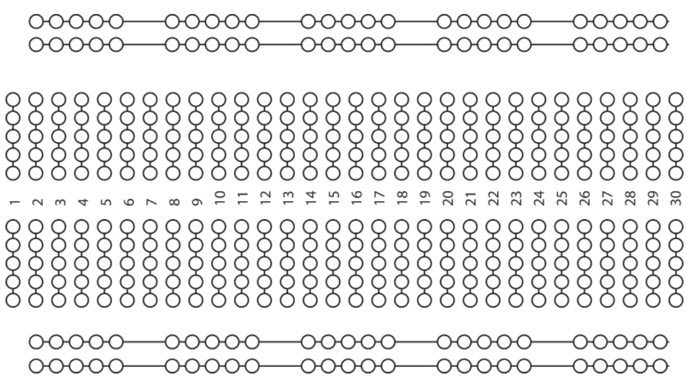
An amplifier takes a signal and makes it larger.
Here we can see a standard Way of representing Our amplifier using a "schematic". We have the integrated circuit (LM386 - which is doing the amplification) and two capacitors.
Voltage is applied at leg 6 an the input signal goes to the chip at leg 3. The chip is grounded at legs 2 and 4.The output signal comes from leg 5.



THE BREADBOARD

A breadboard allows us to prototype circuits without having solder. The legs of components and wires simply slot into the holes (see upper image). The lower image shows how the breadboard is connected below the surface

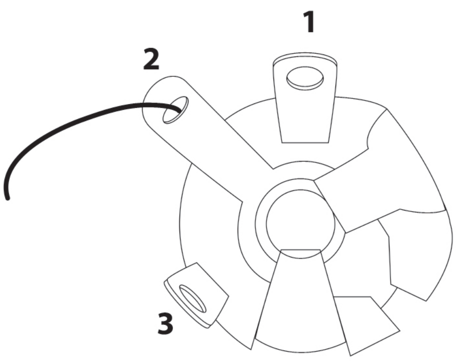




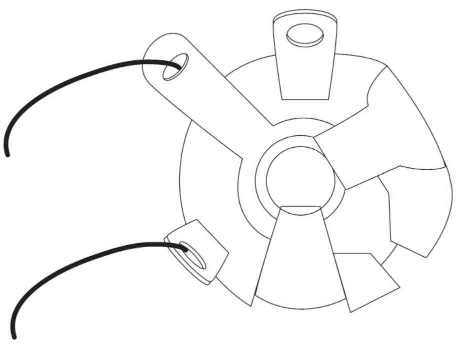
PREPARATION

PREPARING THE INPUT AND SPEAKER

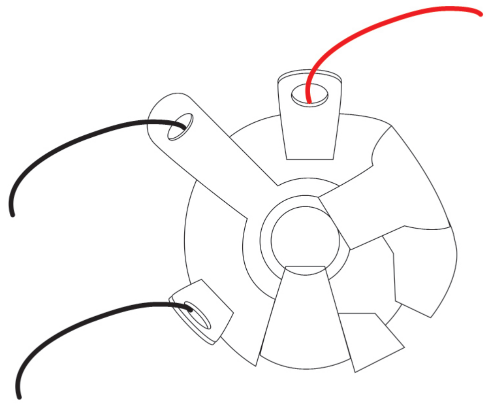
Step 1. Preparing the Input (part 1)
Before we get started we have to prepare our input.
Solder the end of the black wire coming from the battery connector, to the middle lug of the input jack.



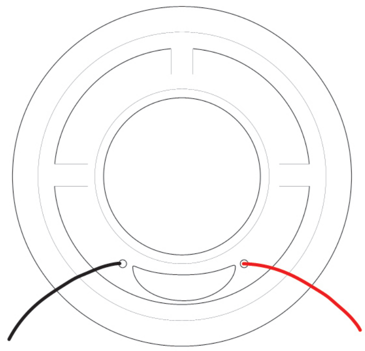
Step 2. Preparing the Input (part 2)
Next take one of your other long black wires and solder it to lug 3



Step 3. Preparing the Input (Part 3)
Finish preparing the input by soldering the long orange wire to lug 1

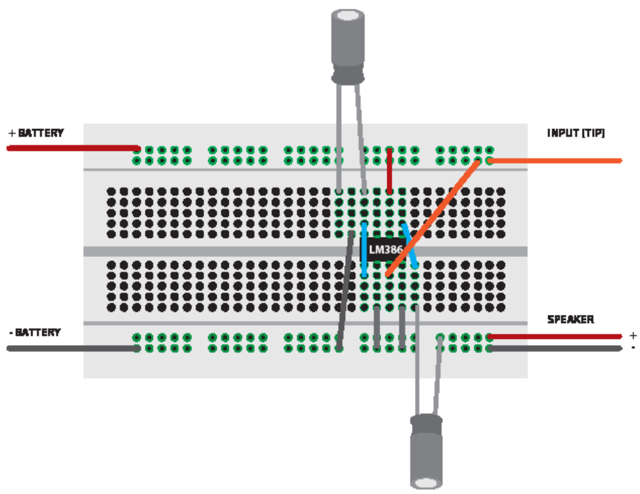


Step 4. Preparing the speaker
Solder a long black wire and a long red wire to each of the lugs on the back of the speaker.
It doesn't matter which lug the wire goes to.



PUTTING THE BOARD TOGETHER

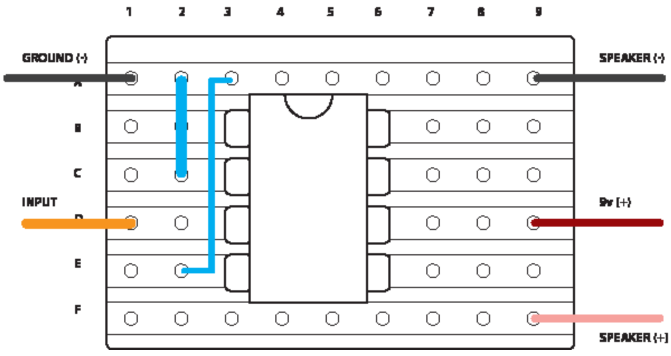
The completed breadboard is shown below. However, it is good practice to see if you can make the circuit from the schematic rather that just copy it. Start by placing the chip across the gap in the middle of the breadboard with the notch facing left.



LET'S MAKE AN AMPLIFIER!

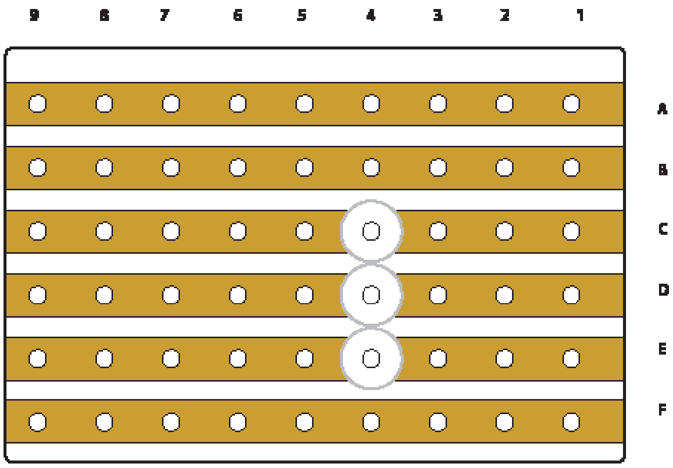
THE VEROBOARD LAYOUT

Here we can see the layout of our components on the veroboard as well as the various connection points for the battery, speaker and input jack.

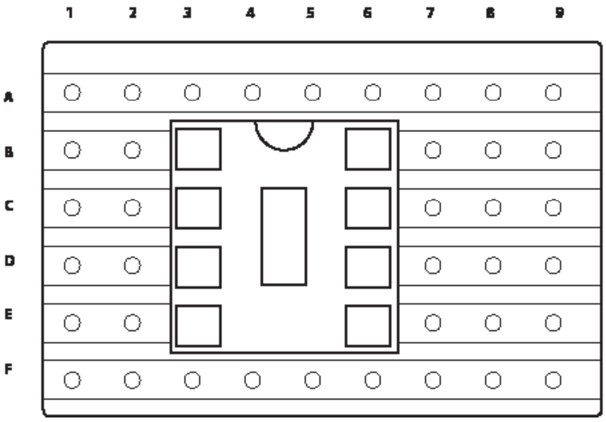


TRACE CUTS

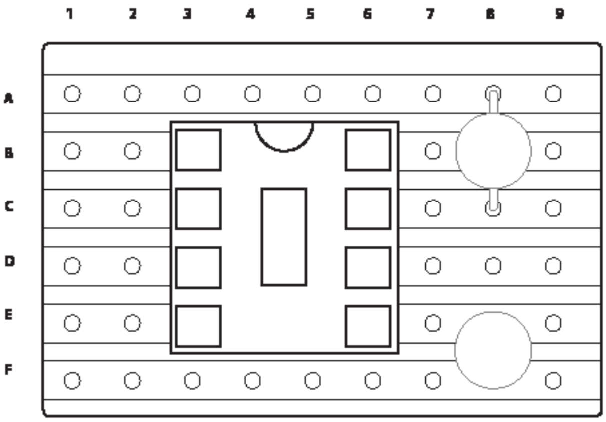
Before we start putting the veroboard together, note that are some cuts to the veroboard on the metals side.
Be careful! Because the cuts are on the metal side, the coordinates will seem to be in reverse



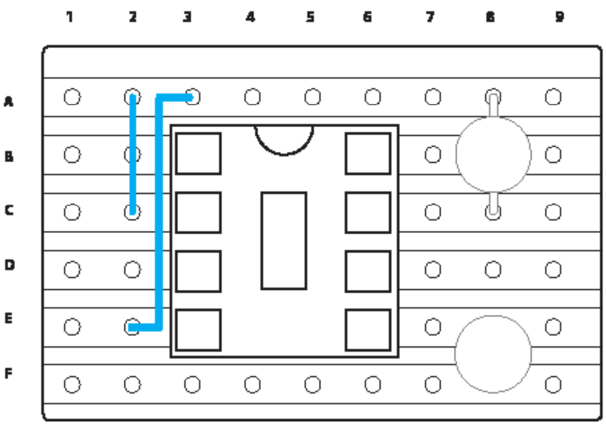
STEP 1: SOLDERING THE IC SOCKET
Place the IC socket into the board as shown in the picture (fro the back of veroboard)



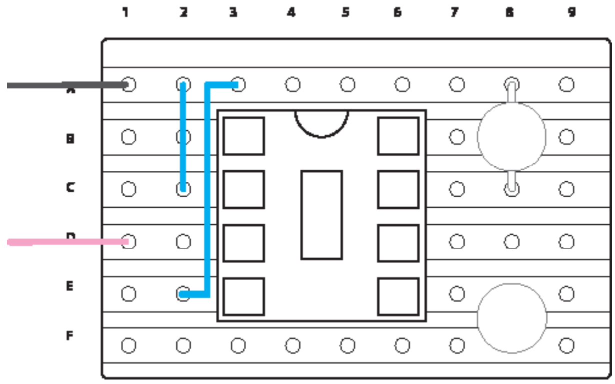
STEP 2: PLACING THE CAPACITORS
Place the Capacitors onto the board as shown in the diagrams. Make sure you have the ground legs of the capacitors orientated correctly.
Be Careful! The negative leg goes towards ground



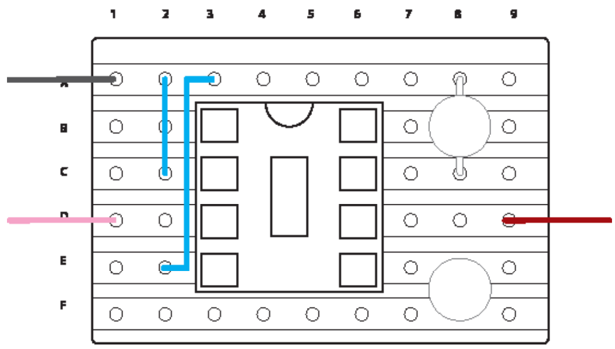
STEP 3: THE JUMPER WIRES
Now solder two small piece of ‘jumper’ wires to the board as shown below. Do the short one first to make it easier for yourself.



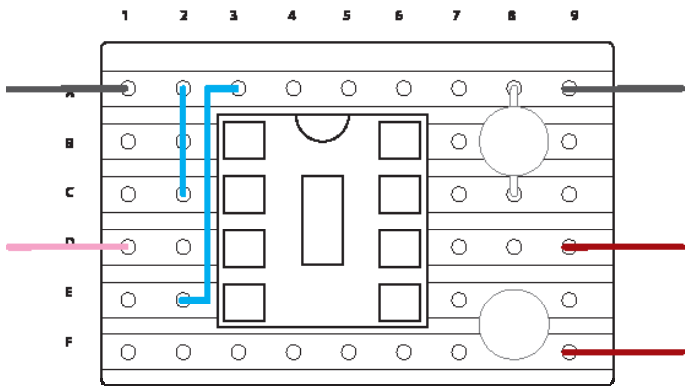
STEP 4: THE INPUT CONNECTIONS
Now connect the black and orange wires fro the input socket to the board as shown below



STEP 5: CONNECTING THE BATTERY
Now solder the red wire from the battery to the board as shown.
Before we solder the speaker to the board we need to put the speaker through the front or our enclosure. Once through, we can solder the two wires to the veroboard.



Solder the red and black wires coming from the speaker as shown below.



FINISHING UP!

If you haven't done so already, place the IC into the holder. Remember to match the notch on the IC and the notch on the holder.
Place the battery and veroboard into the enclosure and use a bit of mounting tape to insulate the board and stick them to the enclosure
Finally, test your amp, and if it is working, screw on the back of the enclosure.
Well done! You've just made an amplifier that can be used with electrical musical instruments such as electric guitars and synthesizers.

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