Welcome to the exciting world of Digital Electronics!

Who is this kit intended for?

This kit is intended for anyone from ages 13 and above and assumes no previous knowledge in the field of hobby electronics. The instructions will guide you step by step on how to build the whole Piano using common practices and techniques, and if you are interested in understanding how this Piano works and learn more about the electronics involved you can later watch the Learn video by following the link.

Important notes

This Piano acts as a demonstrational piece. The electronic circuit was designed in a minimalistic way in order to maintain simplicity; therefore this piano was never intended to be used as an accurate musical instrument.

If you find yourself having difficulties with the build you can follow the step by step build video at **BuildAPiano.xoftc.com**

Never power this piano with anything other than a standard 9V battery!

Before you start it is advised to do the following:

1. Review the page describing the contents of this kit and check that all the listed parts are present.
2. Prepare by your side a Color Marker or a thick Pen. You will also need a small wire cutter or a pair of scissors, and a small flat headed screwdriver.

How to follow the build guide

This guide will instruct you step by step on how to assemble the piano. Each step will provide specific information that will be used throughout the entire build.

Amongst the documentation you will find a sheet with a schematic printed on it, this schematic describes the electronic circuit that you are about to build and it is your blueprint for every step of the build. Each building step holds written instructions describing the exact positions that components should be mounted on the breadboard; it also holds an image of the breadboard with the components that should be added highlighted in blue.

On the left side of each step you will find a schematic of the line that you will be building in each step so that you can follow your work on the blueprint. Since the blueprint schematic can get somewhat confusing, a common practice before carrying out each step is to mark the line on the blueprint using a Marker. So before you start building each step first review the schematic, trace the line or components that you will be working on and mark the whole line.

At the end of this build all the lines on your blueprint page should be marked and that will be an indication that you didn't forget any of the connections.

Each step will also provide graphical instructions and symbols. Pay careful attention to them and ensure to perform the instructions as described in order to get the best results.

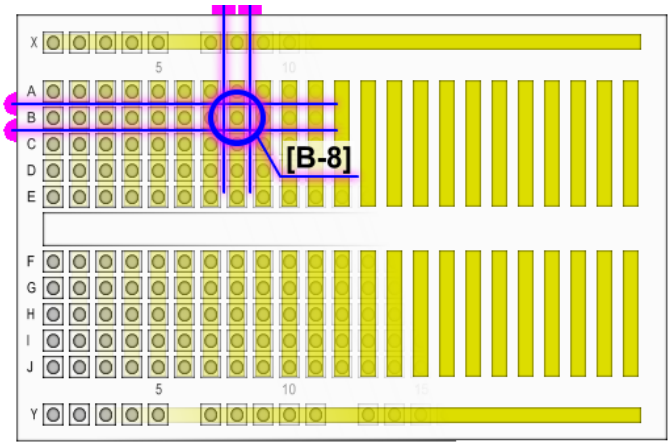
The scissors symbol will remind you to trim the leads on each step where it is required. 

You will start this build first with the components in bag **A** and later move on to the components in bag **B**.

We hope that you will enjoy this build

Have fun!

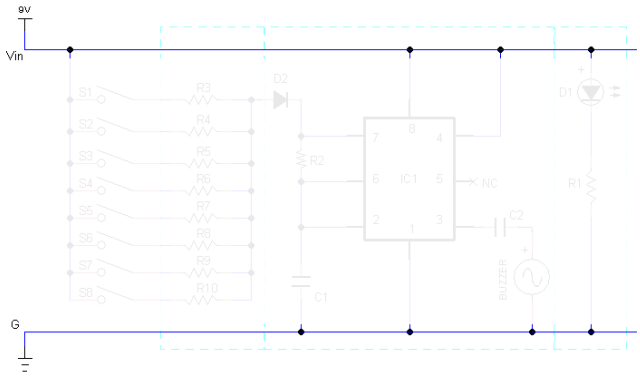
The Solderless “Breadboard”



Included with the kit you will find a Solderless “Breadboard”. The Breadboard is a prefabricated template of metal wires that allows us to tap into-or connect to different components and wires without the need to solder them together in order to make a connection, and it is generally used in the electronics world for learning and testing.

In each step you will find coordinates that will guide you exactly in which one of the holes to place each component. Place each component exactly as shown in each step.

<u>Step 1 – Extend the POSITVE and NEGATIVE rails</u>

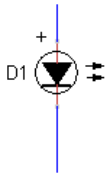


Connect the Red wire coming out of the battery clip to the rail on the breadboard marked **[X]**

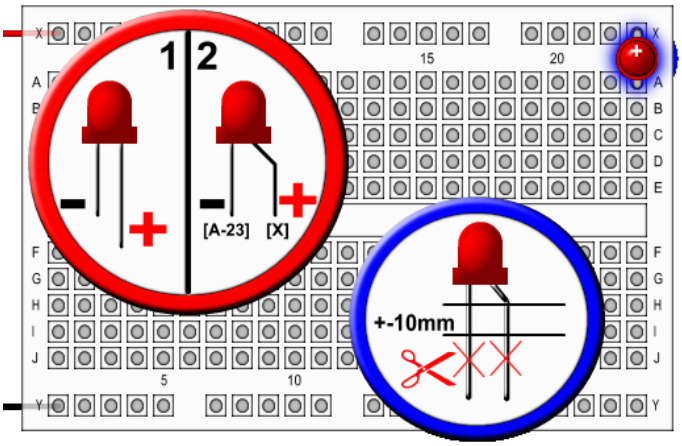
Connect the Black wire coming out of the battery clip to the rail on the breadboard marked **[Y]**

From now on the X rail will be the **POSITIVE (+)** and the Y rail will be the **NEGATIVE (-)**

<u>Step 2 – Connect D1 (Light Emitting Diode)</u>



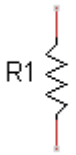
A Light Emitting Diode or in short “LED” is a device that when connected produces light and acts as a visual indicator to that the circuit is ON.



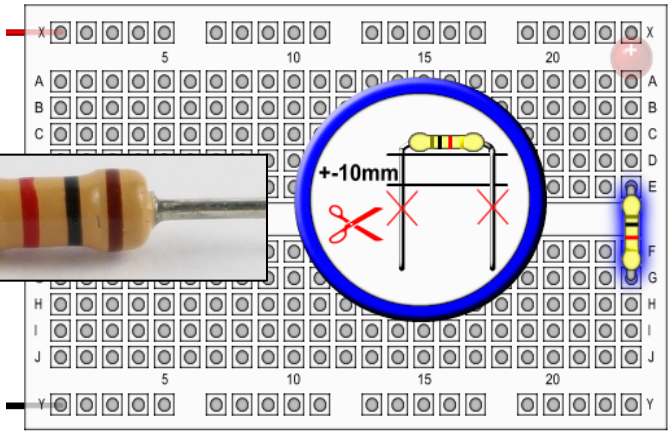
The LED has a **POSITIVE** lead and a **NEGATIVE** lead. For the LED to work it is important to connect it in the right direction. First bend the LED’s **POSITIVE** lead as shown in the image and trim the excess parts of the leads so that is will fit nicely into place.

Place the LED on the breadboard with the **POSITIVE** lead in the **[X]** rail and the **NEGATIVE** lead in **[A-23]**.

<u>Step 3 – Connect R1 (Resistor)</u>



Resistors are the most basic electronic components and they are used to control how much current all the other components will receive from the battery.
Resistors do not have specific leads and they can be connected in either direction.



The R1 resistor can be found in bag **A** and has the color code of **Brown, Black, Red,** and **Gold.**

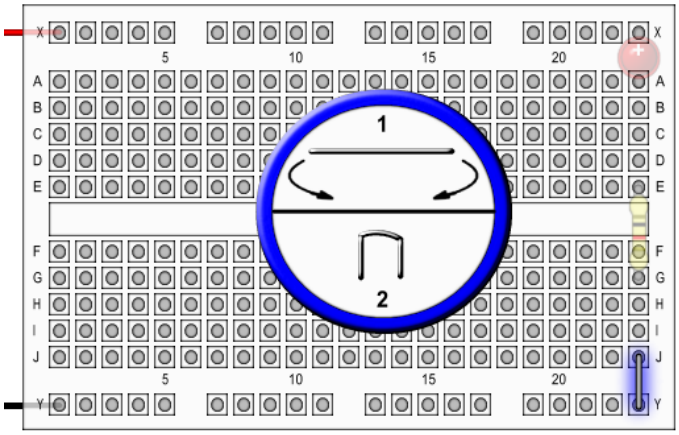
Bend the leads as shown in the image and trim the excess parts off the leads. Place the Resistor with one lead into **[E-23]** and the other lead in **[G-23]**.

Step 4 – Connect R1 to Ground

In order to make connections across different areas of the breadboard we use copper wires also called "Jumpers" because we "Jump" from one section to another.

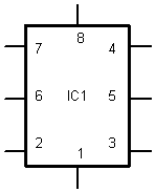
Cut a **2cm** piece of jumper wire and bend it as shown in the image.

Place one end of the wire in **[J-23]** and the other end in the **NEGATIVE** rail **[Y]**.



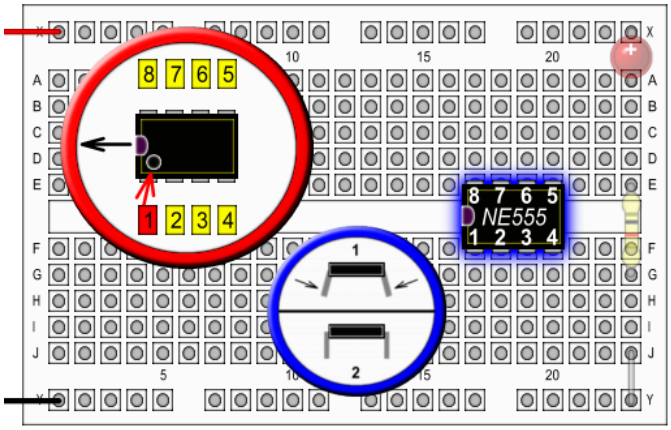
Make sure that the jumper sits flat on the board. If the leads are too long you can trim them to fit.

Step 5 – Place IC1 (Integrated Circuit)



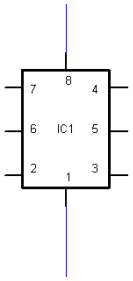
Integrated Circuits or in short "ICs" are devices that perform one or more specific operations. The NE555's function is to produce continues states of ONs and OFFs, therefore it is called a "Switching Device".

Notice the groove in the package, this should normally point LEFT. While pointing left, the numbering of the individual pins will start from the bottom left in a circle to the top left. When there is no groove on a specific chip there will always be a mark like a circle or a dot.



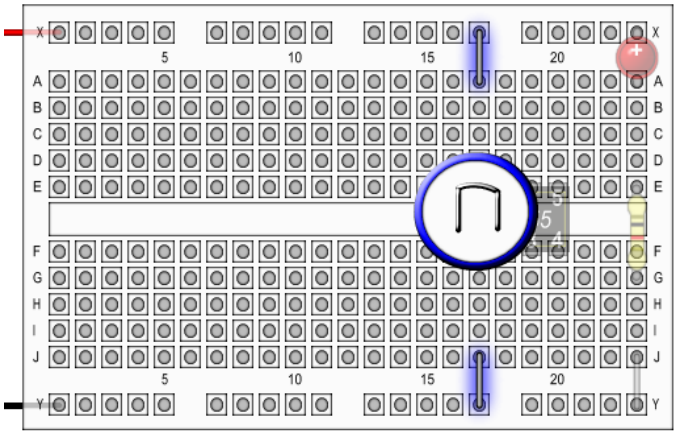
Place the IC with pins 1 and 8 falling on column number 17 so that pin 1 is positioned in **[F-17]** and pin 8 in **[E-17]**.

Step 6 – Connect the Power and Ground of the IC



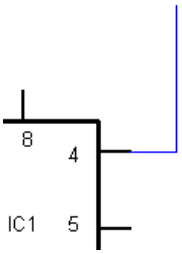
Just like any device (TV, Computer, Microwave, etc') the NE555 Switching Device must also receive power in order for it to operate.

Prepare 2 jumpers 2cm long. First connect the **POSITIVE** of the IC (pin 8) by placing one end of the jumper in the **POSITIVE** rail **[X]** and the other end in **[A-17]**.

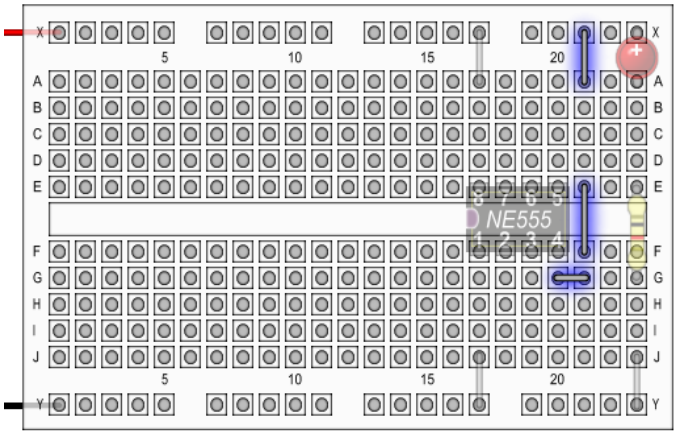


Now connect the **NEGATIVE** of the IC (pin 1) by placing one end of the jumper in the **NEGATIVE** rail **[Y]** and the other end in **[J-17]**.

Step 7 – Turn OFF the RESET Function of the IC

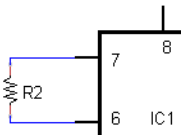


*Almost every IC has a RESET option that enables us to reset it if needed without needing to turn off the whole circuit. The NE555 has its reset function on pin 4, and we are going to disable it by connecting it to the **POSITIVE** rail.*



The first jumper will be about 1.5cm long and will connect between **[G-20]** and **[G-21]**. The second jumper will be about 2.5cm long and will connect between **[F-21]** and **[E-21]**. The third jumper will be about 2cm long and will connect between **[A-21]** and **[X]**.

Step 8 – Connect R2 (Resistor)

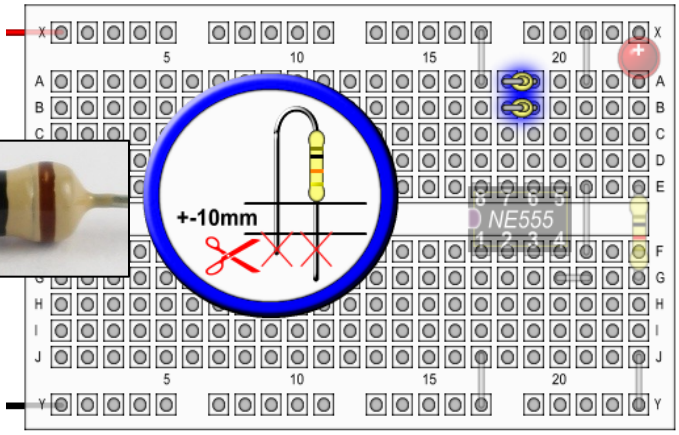


R2 is a single resistor with a value of 5000Ω, however since we don't have a standard value of 5000Ω we will use 2x 10,000Ω resistors in what is called a Parallel connection.

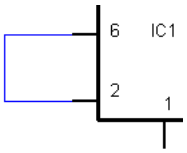
The two 10KΩ resistors can be found in bag **A** and they have the color code **Brown, Black, Orange,** and **Gold**.

Connect the first resistor with one lead in **[A-18]** and the other lead in **[A-19]**.

Connect the second resistor with one lead in **[B-18]** and the other lead in **[B-19]**.

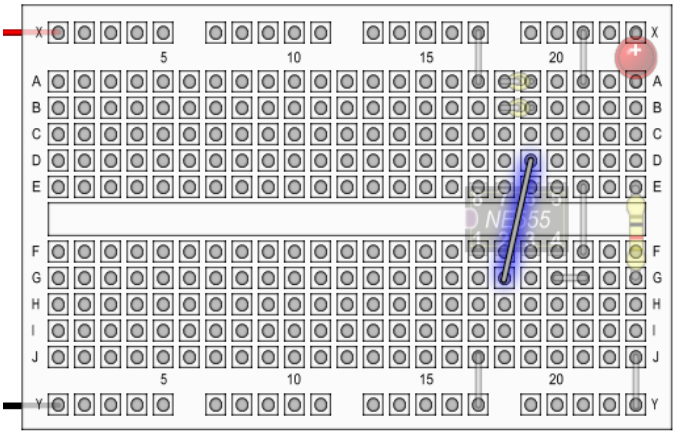


Step 9 – Connect the Trigger pin of the IC

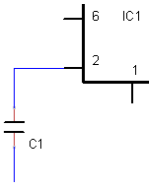


*The trigger pin on the NE555 IC is the ON/OFF button. When we connect it to the **POSITIVE** we activate the NE555 IC, and when we connect it to the **NEGATIVE** we "deactivate" the NE555 IC.*

Cut a **4cm** piece of jumper wire and bend it into a U shape. Connect one end to **[G-18]** and the other end into **[D-19]**.

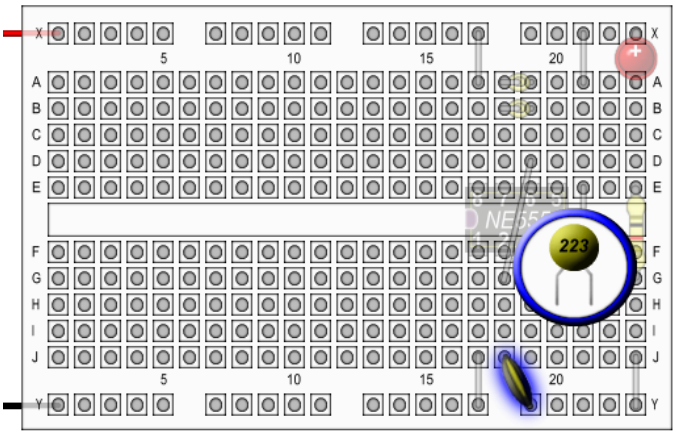


Step 10 – Connect C1 (Capacitor)

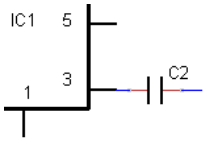


Capacitors are devices that can store a charge and once they are completely full they will release their charge and start filling up again.
*Some capacitors have a specific **POSITIVE** and **NEGATIVE** leads, however in this build we are using a Ceramic low value capacitor and it is not important in which direction it is connected.*

Take the 22nF Capacitor marked "**223**". Connect one end in **[J-18]** and the other end in the **NEGATIVE** rail **[Y]**.

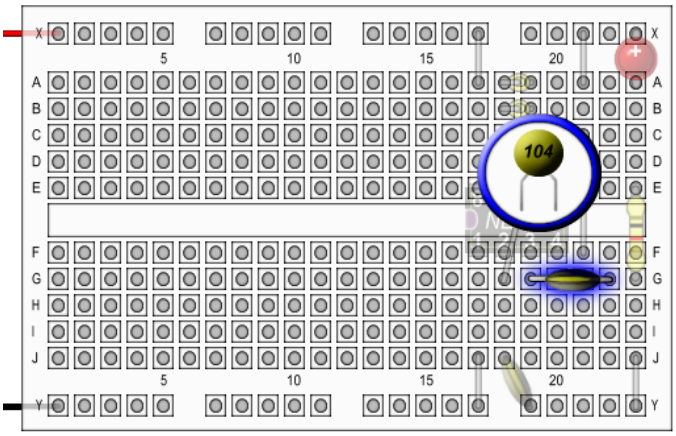


Step 11 – Connect C2 (Capacitor)



Capacitors can fill up with charge and then discharge. One of the uses for this action is to filter out a specific "noise" that comes with the signal output of the NE555.

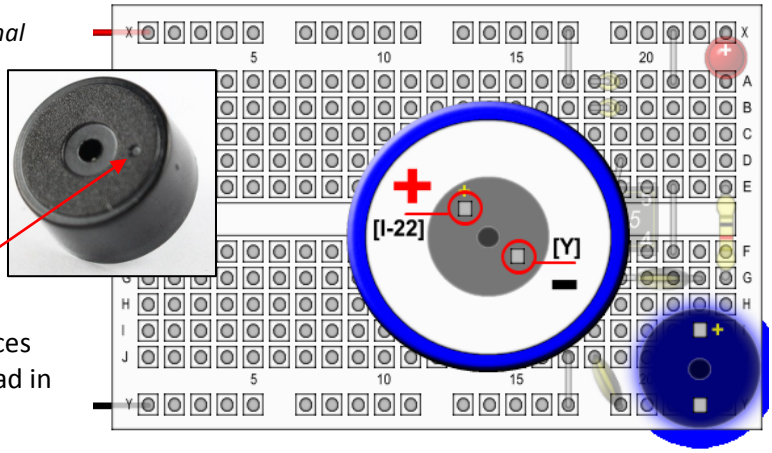
Take the 100nF Capacitor marked "**104**". Connect one end in **[G-19]** and the other end in **[G-22]**.



Step 12 – Connect the Buzzer

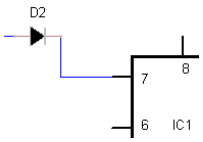
The Buzzer is a device that can convert an output signal into sound. It has a small metal plate inside that curves in and out very fast; that will push the air in front of it and this will produce a tone.

The Buzzer has a **POSITIVE** lead and a **NEGATIVE** lead. It is important to connect it in the right direction for it to work.



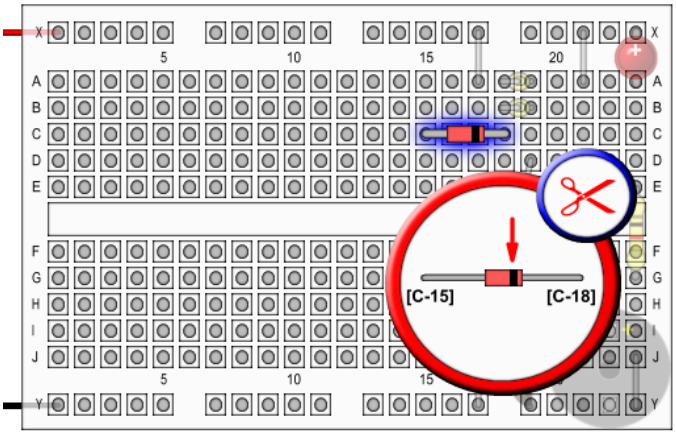
Take the Buzzer and align it so that the marked dot on it faces up. This marks the **POSITIVE** lead. Connect the **POSITIVE** lead in **[I-22]** and the other lead which is the **NEGATIVE** into **[Y]**.

Step 13 – Connect D2 (Diode)



A Diode is a device that allows the Current to flow only in one direction and does not allow it to flow back. It is used to control the flow to and from different devices.

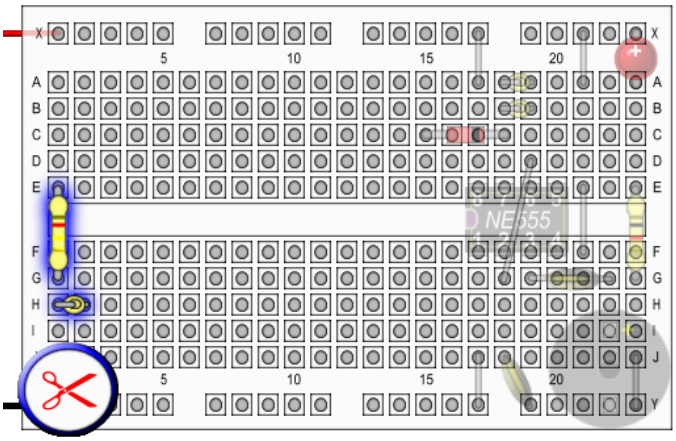
The Diode has a **POSITIVE** lead and a **NEGATIVE** lead. Depending in which direction we connect it the current will flow from the **POSITVE** to the **NEGATIVE** but not back.



Take the Diode and note the marked line. This line marks the **NEGATIVE** lead. Connect the **POSITIVE** end in **[C-15]** and the **NEGATIVE** lead in **[C-18]**.

Step 14 – Connect R3 (Resistor for the C4 Note)

The R3 Resistor has a value of 240,000Ω (240KΩ). Since there is no standard value Resistor of 240KΩ we use 2x 120KΩ Resistors in what is called a Serial connection.

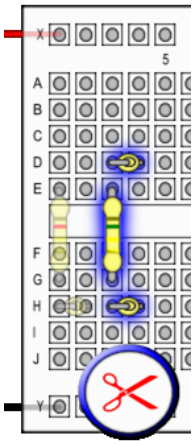


Take the bag marked "**C4**" and take out the two 120KΩ Resistors.

Bend and trim the first Resistor and connect one end in **[H-1]** and the other end in **[H-2]**. Bend and trim the second Resistor and connect one end in **[G-1]** and the other end in **[E-1]**.
You will repeat this same process for the following 7 steps.

Step 15 – Connect R4 (Resistor for the D4 Note)

The R4 Resistor has a value of 214KΩ. We will use 3 Resistors in Series in order to reach as close as possible to this value, 150KΩ + 47KΩ + 18KΩ =215KΩ.

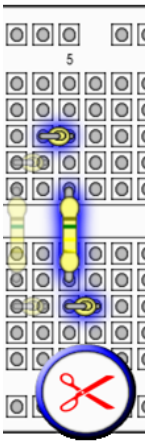


Take the bag marked "**D4**" and take out the 3 resistors. It doesn't matter in which order they are connected.

One will connect between **[H-3]** and **[H-4]**
One will connect between **[G-3]** and **[E-3]**
One will connect between **[D-3]** and **[D-4]**

Step 16 – Connect R5 (Resistor for the E4 Note)

The R5 Resistor has a value of 189KΩ. We will use again 3 Resistors in Series.
150KΩ + 22KΩ + 18KΩ = 190KΩ.

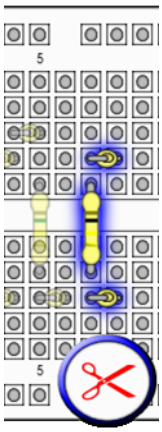


Take the Resistors from the bag marked "**E4**". Don't forget to trim the leads so they fit nicely into place.

One will connect between **[H-5]** and **[H-6]**
One will connect between **[G-5]** and **[E-5]**
One will connect between **[C-4]** and **[C-5]**

Step 17 – Connect R6 (Resistor for the F4 Note)

The R6 Resistor has a value of 178KΩ and we will use 100KΩ + 56KΩ + 22KΩ = 178KΩ.

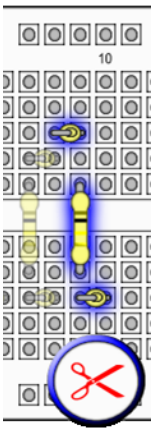


Take the Resistors from the bag marked "**F4**".

One will connect between **[H-7]** and **[H-8]**
One will connect between **[G-7]** and **[E-7]**
One will connect between **[D-7]** and **[D-8]**

Step 18 – Connect R7 (Resistor for the G4 Note)

The R7 Resistor has a value of 157KΩ. We will use 100KΩ + 56KΩ + 1KΩ = 157KΩ.

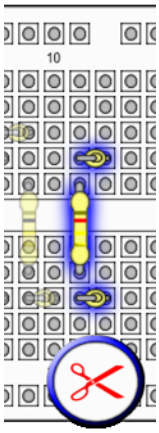


Take the Resistors from the bag marked "**G4**".

One will connect between **[H-9]** and **[H-10]**
One will connect between **[G-9]** and **[E-9]**
One will connect between **[C-8]** and **[C-9]**

Step 19 – Connect R8 (Resistor for the A4 Note)

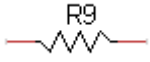
The R8 Resistor has a value of 139KΩ and we will use 120KΩ + 18KΩ + 1KΩ = 139KΩ.



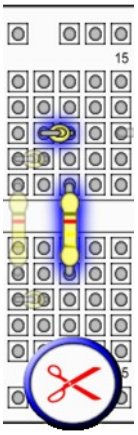
Take the Resistors from the bag marked "**A4**".

One will connect between **[H-11]** and **[H-12]**
One will connect between **[G-11]** and **[E-11]**
One will connect between **[D-11]** and **[D-12]**

Step 20 – Connect R9 (Resistor for the B4 Note)



The R9 Resistor has a value of 123KΩ. We will use 120KΩ + 3.3KΩ = 123.3KΩ.



Take the Resistors from the bag marked "**B4**".

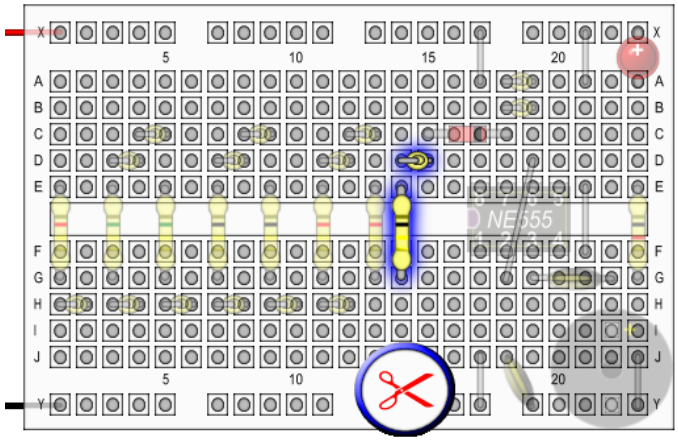
One will connect between **[G-13]** and **[E-13]**
One will connect between **[C-12]** and **[C-13]**

Step 21 – Connect R10 (Resistor for the C5 Note)

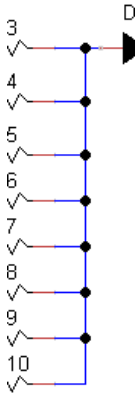
The R10 Resistor has a value of 115KΩ and we will use 100KΩ + 15KΩ = 115KΩ.

Take the Resistors from the bag marked "**C5**".

One will connect between **[G-14]** and **[E-14]**
One will connect between **[D-14]** and **[D-15]**



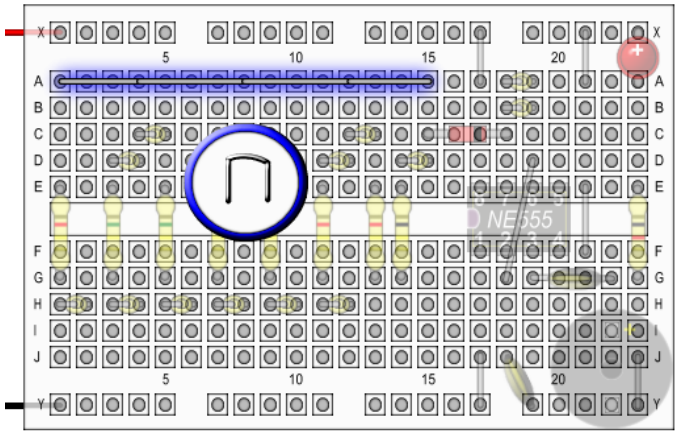
Step 22 – Connect R3 to R10



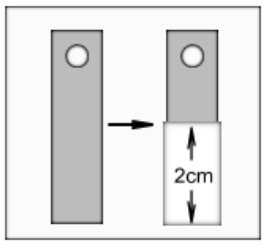
Cut 4 pieced of 3cm long jumper wire.

One will connect between **[A-1]** and **[A-4]**
One will connect between **[A-4]** and **[A-8]**
One will connect between **[A-8]** and **[A-12]**
One will connect between **[A-12]** and **[A-15]**

At this point you have finished the circuit. The next step is to build the frame and connect each key to one of the notes.



Step 23 – Prepare the Keys

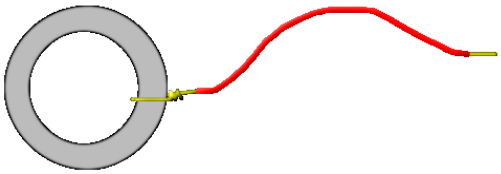


As switches or "keys" we use cut pieces of sheet metal. Since bare metal is conductive and electricity can flow from the switch into our body, we need to ensure that each key has an insulation layer to prevent this. This insulation will also protect from the sharp edges.

Careful – the bare keys have sharp edges. Handle with care. For each one of the 8 keys cut a 2cm piece of double sided tape and stick it as shown in the image. Do not peel the top side of the tape.

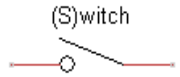
Step 24 – Prepare the Key Connectors

In order to connect each of the switches we need to attach a wire to it. We will do this by wrapping a piece of bare wire around a metal washer disk.

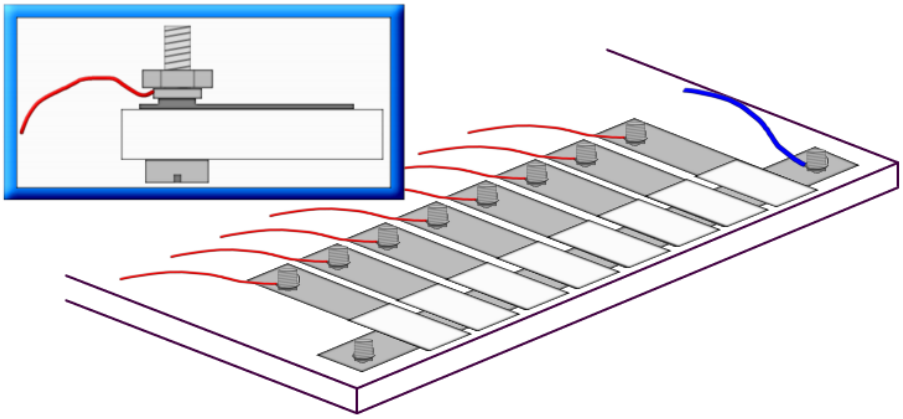


Take each one of the 9 colored wires and wrap the longer exposed end around the washer as shown in the image. At the end of this process you will have 1 washer left over.

Step 25 – Build the Frame and Keys

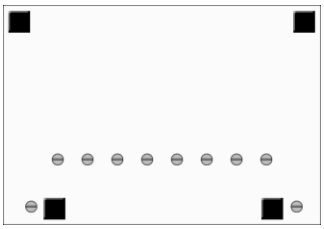


Take the long strip of metal with the hole on each side. Stick a 10cm piece of double sided glue on the **flat** bottom side.



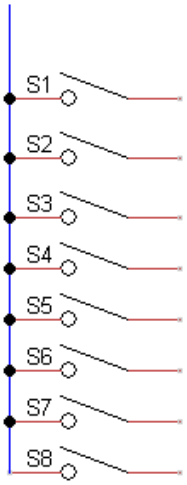
Peel the double sided tape and stick the strip aligned with the holes in the sheet of plexyglass. Reinforce the connection using two screws on either side inserted from the bottom of the plate. The left over washer will be used for the left screw while for the rest use the washers connected to the wires as shown in the image.

Stick the 4 feet at the bottom side of the plexyglass sheet as shown in the image.



Make sure that all the screws are fastened.

Step 26 – Connect the Keys to the Circuit

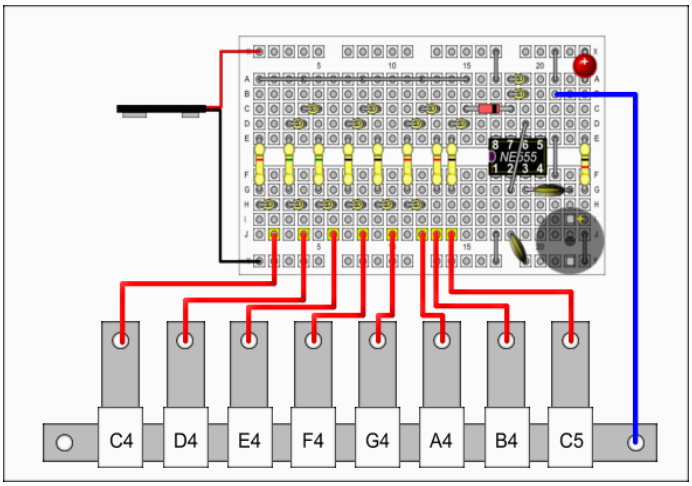


The final step is to connect each one of the switches to its resistor. Connect each wire end according to the list below:

S1 which is the C4 key will connect to [J-2]
S2 which is the D4 key will connect to [J-4]

S3 will connect to [J-6]
S4 will connect to [J-8]

S5 → [J-10]
S6 → [J-12]
S7 → [J-13]
S8 → [J-14]



Once you have connected all of the keys, slightly bend each one of the keys upwards so that it does not touch the bottom strip. Each key should be about 2-3 millimeters above the metal strip but not too high.

Step 27 – Final Preparations

You are finished with the building process and it's time to test your piano and play some tunes. But before you go about connecting the battery to it first there are some important checks you need to do to ensure that everything is properly connected and nothing can go wrong. Follow the list below and carry out each check:

1. Go back to step 1 and briefly review each step and the connections you made to verify that there are no mistakes.

2. Check that there are no wires touching each other unless they are on the same rail or column. If you have components or jumper wires sticking out too much carefully remove them, trim the excess leads and place them back in place. Make sure you place them back exactly where they were.

3. check that all the screws are tight and none of the keys are loose or wiggling

Step 28 – Connect The Battery and Test Your Piano

Once you followed all 3 checks and everything seems to be in place it's time to test the piano. Before you connect the battery read the following:

Use only a standard 9V battery!

If the LED doesn't light up once the battery is connected disconnect the battery immediately and refer to the troubleshooting video online!

Normally electronic components produce a small amount of heat which in this circuit will be barely noticeable. If you are feeling excessive heat coming off one of the components to the point where you can't touch it disconnect the battery and refer to the troubleshooter video online!

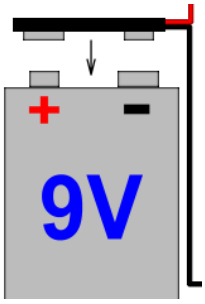
Disconnect the **POSITIVE** wire on the battery clip from the **[X]** rail and place it aside ensuring that it doesn't touch any other components or the battery. Now connect the battery to the battery clip, and once the battery is securely connected reconnect the POSITIVE wire back to the **[X]** rail and watch how the LED turns ON. Now you can try to play different tunes by following the basic notation sheet included. Use the leftover piece of double sided tape to stick the battery nicely in place about **2cm** to the left of the Breadboard.

If you want to learn more about this circuit and how it works with more in-depth information go to **BuildAPiano.xoftc.com** and click on the Learn video. On the same page you will also find all the resources and video tutorials for this kit including a step by step build guide for reference, a video showing how to play each of the tunes included, and a set of downloadable instructions in case you want another copy amongst some other extra resources.

Once you are finished playing with the piano:

Always disconnect the battery from the battery clip!

Always place the piano well away from the reach of small children and animals



We hope that you have enjoyed this build and that we managed to get your curiosity going towards a new and exciting hobby of electronics.

The xoftc.com Team
www.xoftc.com