NAISAtron construction manual

Please read this manual in its entirety before starting. The more familiar you are with the instructions, the less likely you are to make a mistake!

Introduction

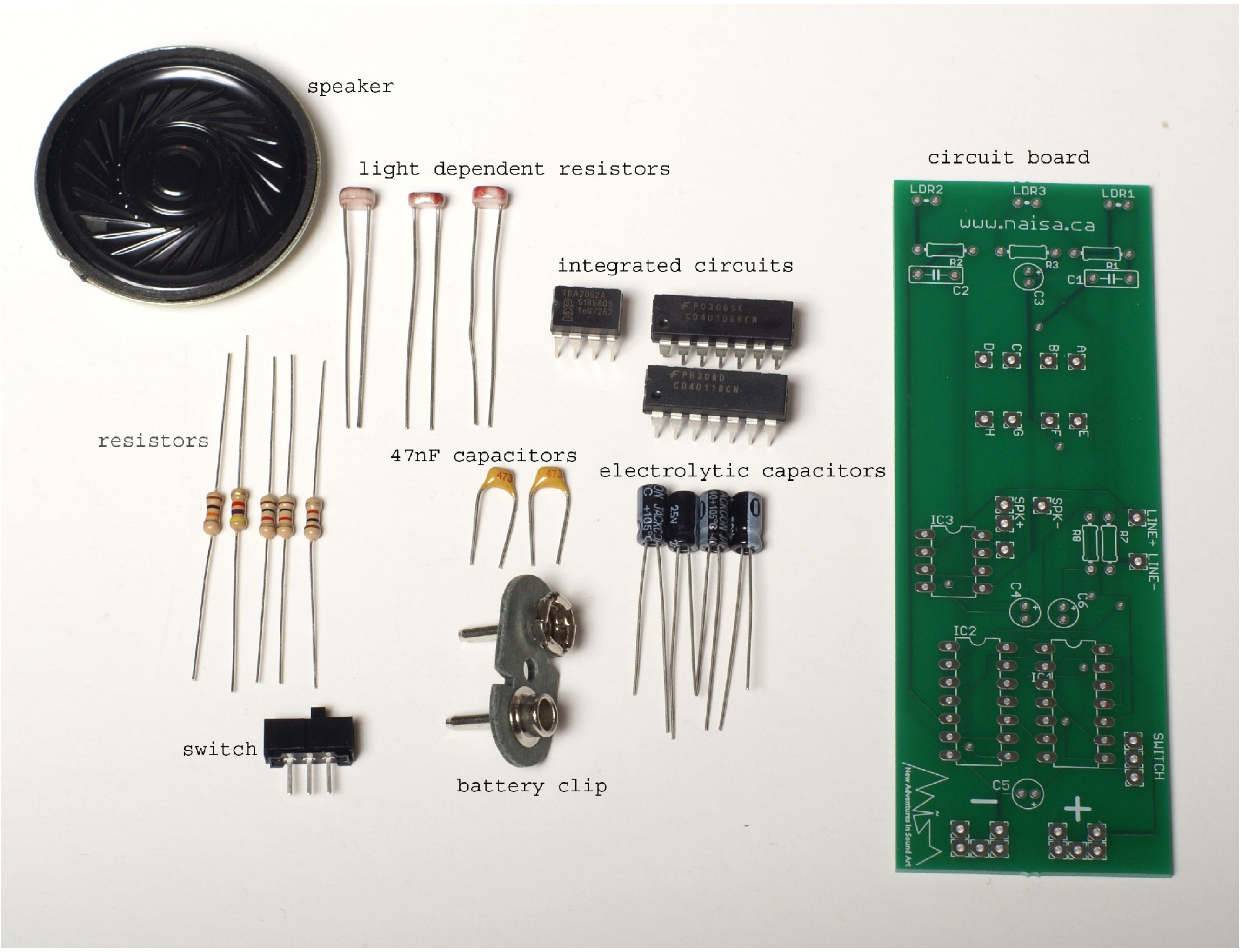
The NAISAtron is supplied in kit form. You should be familiar with the basics of electronic construction, and have the following tools on hand:

Soldering iron A low power (40w or less) iron, suitable for fine soldering. Large "guns" are not suitable, nor are the "cold" soldering irons sold on late-night TV. Best is a temperature-controlled soldering station, such as the ones made by Weller, Hakko, or numerous Chinese companies.
Solder Use only small-diameter solder made for electronics work. Most electronics solder is an alloy of lead and tin, and has a flux core. Lead is toxic to people and the environment, and so you may choose to work with a lead-free solder. These are usually silver-based, and are significantly more expensive than lead solders. Do not use silver solder that is not specifically made for electronics, non-flux cored solder, or acid-cored solder.
Needle nose pliers or hemostat forceps for bending leads. The finer the better. Good ones can often be found in the fishing department of sporting-goods stores.
Wire Cutters Preferably the flush-cutting type that have a flat cutting edge, which can cut wires cleanly off against the circuit board without leaving a protruding spike. In a pinch, nail clippers will work.
Wire strippers The inexpensive adjustable ones are fine, as there are only a few wires to strip in the project. If you want to continue with electronics as a hobby, consider getting the type which have pre-set hole sizes for various wire gauges. Make sure it can strip wires as small as 24AWG. (the bigger the number the smaller the wire)
Eye protection Soldering can fling molten metal and flux at your eyes, and clipped wires can become tiny, needle-sharp missiles. You must wear eye protection while building electronic circuits.

The following tools are optional, but may be useful:

"Helping hands" These tools have a pair of alligator clips on ball-and-socket joints, and are useful for holding parts in place while soldering.
Desoldering braid This is a fine copper braid impregnated with soldering flux, and is used to remove solder from a joint in case you need to remove a part. You will find this very handy if you make a mistake, or if you want to modify your NAISAtron.
Desoldering pump A.K.A. "solder sucker" This is a mechanical suction device which can remove solder from a joint. While the desoldering braid will work alone, it's best to use the solder sucker first, then clean up with the braid. Don't waste your money on the cheap ones with a rubber bulb, get a proper spring-loaded one.
Wet/dry sandpaper You will get better results if you lightly polish the component leads with a small piece of 600 grit wet/dry sandpaper before you solder them.

You will be placing components into the circuit board and soldering them in place. Some components can fit in the board in more than one way- if it is important that a component goes in a certain way, you will be reminded during that step of the assembly. Work slowly and double check every part **before** you solder it (Or better yet, work with a friend, who will check your work). Try to catch your mistakes early, as removing a part once it is soldered into place can be difficult. Work in a well ventilated area with good lighting, and on a surface which won't mind the odd blob of solder, or a bit of heat.



Getting started

First, sort the components out, and organize them.
You should have the following parts:
(1) circuit board
(1) speaker
(1) switch
(3) integrated circuits: TDA7052, CD40106B, and CD4011B,
(3) 1k ohm resistors-brown/black/red (see **How to Read Resistors**)
(1) 10k ohm resistor -brown/black/orange
(1) 4.7k ohm resistor -yellow/violet/red
(3) light dependent resistors
(2) 47 nF capacitors marked "473"
(2) 1μF 50v electrolytic capacitors
(2) 10μF 25v capacitors
9v battery clip

Not shown: wire, double-sided foam tape.
Parts may differ slightly in appearance from those shown.

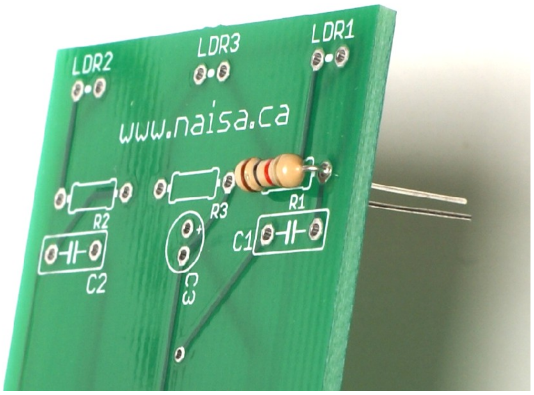
Take care to identify the components correctly. In particular, the different values of resistors and electrolytic capacitors are easily confused, and the 4011 and 40106 integrated circuits look very much alike. If something is missing, contact NAISA, and explain the problem. You may want to use small containers to keep the components organized. An old trick is to use the compartments of a muffin tin.

You will be installing parts in the circuit board. The "top" side of the board is the side with printing on it, the "bottom" side is where most parts are soldered.

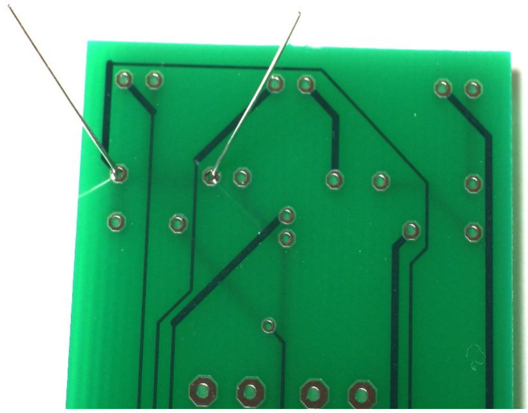
Install the resistors

As you will be placing the parts in the board, then turning it over to solder, it's helpful to install the components in order of how "tall" they are, starting with the smallest. That way, they will be less likely to fall out when you flip the board over. So we'll start with the resistors.
Find the three 1k ohm resistors, (brown/black/red) and, using the needlenose pliers, bend the leads carefully 90°, as close to the body of the resistor as you can, like this:

(don't confuse the 1k resistor with the 4.7k (yellow/violet/red) resistor). If you have the wet/dry sandpaper, polish the leads slightly before putting the resistor in place. Fit the leads into the holes in the position marked **R1,** and bend them outwards slightly to hold the resistor in place, flat against the board. It doesn't matter which way around the resistors go in, they don't have positive and negative leads.

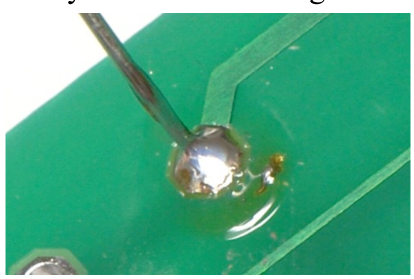


top

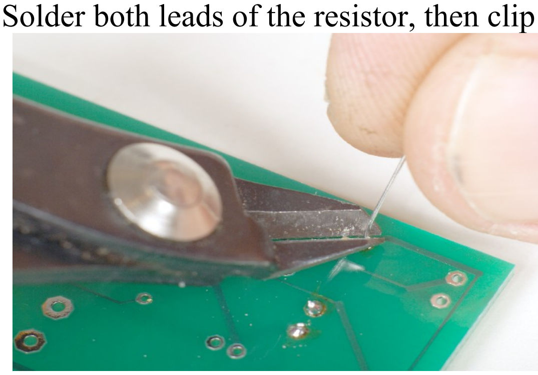


bottom

With the board top-side-down on the work surface, carefully solder the leads in place. You need only solder on the bottom side of the board. (See **How To Solder**) A good solder joint will be shiny, and cover both the lead and the hole smoothly without "blobbing".



Solder both leads of the resistor, then clip them flush with the board, as shown.

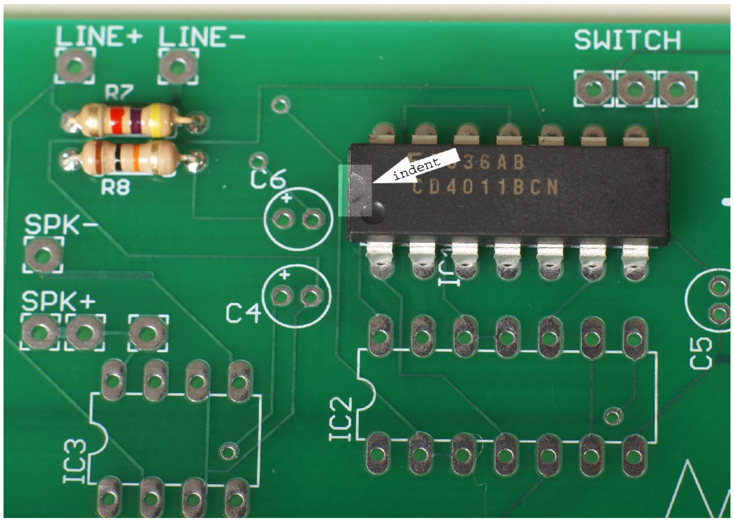


Hold the end of the lead as you cut it so that it doesn't go flying across the room.

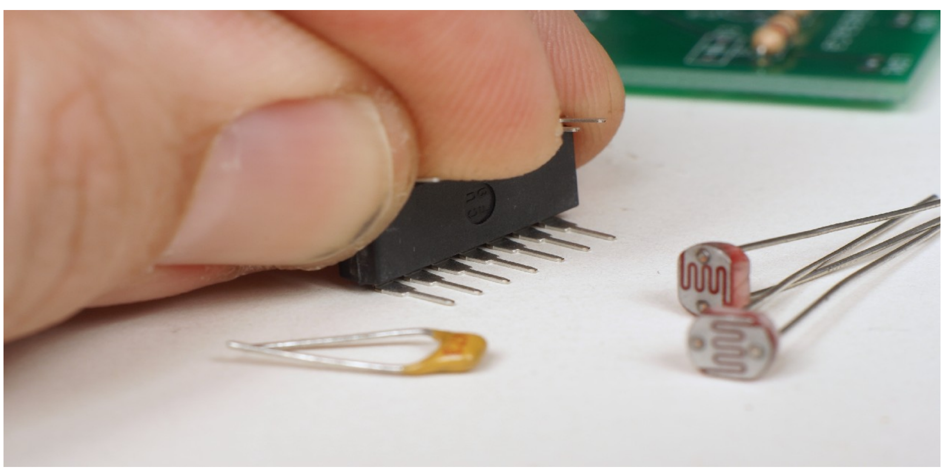
Continue to install the other two 1k resistors in this fashion in the places marked **R2**, and **R3**.
Now mount the 4.7k ohm resistor (yellow/violet/red) in the spot marked **R7,** and the 10k ohm resistor (brown/black/orange) in the spot marked **R8.** Double check the colour codes before you solder them in place!

Install the chips

Now begin to mount the integrated circuit chips. This should be done very carefully as they are easily damaged. Find the CD4011B chip. (it may have several numbers on it, but somewhere you will find the number **4011** on it. It is one of the two larger chips, with 14 pins. The other large chip is the CD40106B. The smaller chip is the TDA7052. Make sure you know which chip is which before you proceed.
Look for the semi-circular indent on one end of the chip

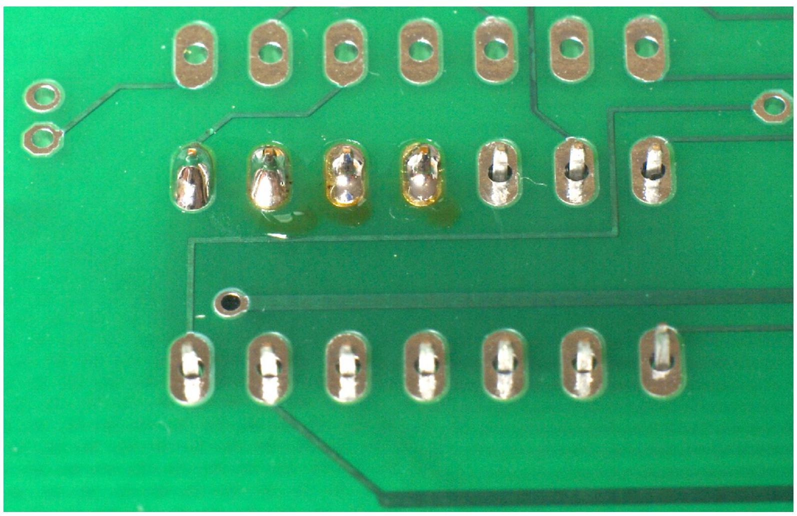


This shows you which way to insert the chip.
The indent should line up with the semicircular mark printed on the chip's outline on the board. *Make absolutely sure you have the right chip in the right place, and it's in the right way around. If you make a mistake here, it will be very difficult to fix.* This is a good time to have a friend double-check your work! The CD4011B chip goes in the spot marked **IC1** When you get the chip, the legs will probably be spread a little too wide to fit in the holes. Place the chip on its side on a flat surface, and *gently* bend the legs inwards very slightly, by rocking the chip's body.



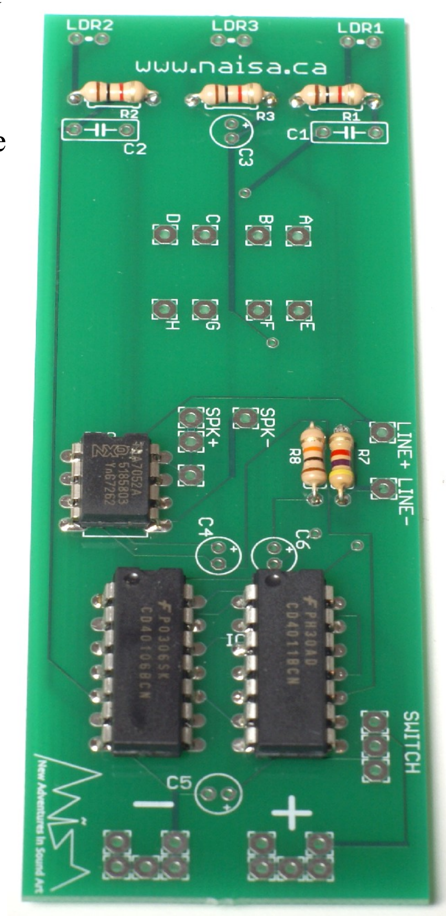
It's important that all the legs bend by the same amount, and remain in a straight line. Do this in two or three steps, checking as you go, until all the legs fit in all the holes. Be very careful here, as it is easy to bend a leg of a chip and fold it under the chip body by accident. Works slowly and carefully, until the chip is seated properly in the holes as seen above. Then turn the board over, and carefully solder each leg, as you did with the resistor. It's not necessary to clip the leads shorter, but you can if you want. Make sure you solder all 14 legs. The chips are sensitive to heat and static electricity, and while you will probably have no problems, you should try not to overheat them when soldering, and to avoid wearing wool or synthetic clothing while working on them. If your room is exceptionally dry you may want to boil a kettle or use a humidifier to increase the humidity.

This picture shows a partly soldered chip.



You should double-check that all legs are through their holes, and that the correct chip is in the correct spot, and the right way around, before you solder the first pin.

Once you've got the CD4011B chip, **IC1**, in place, it may be time to take a quick break, then mount **IC2** the CD40106, and **IC3,** the TDA7052 in their correct places. Remember, double-check that everything is the right way around before you solder! Your board should now look like this:

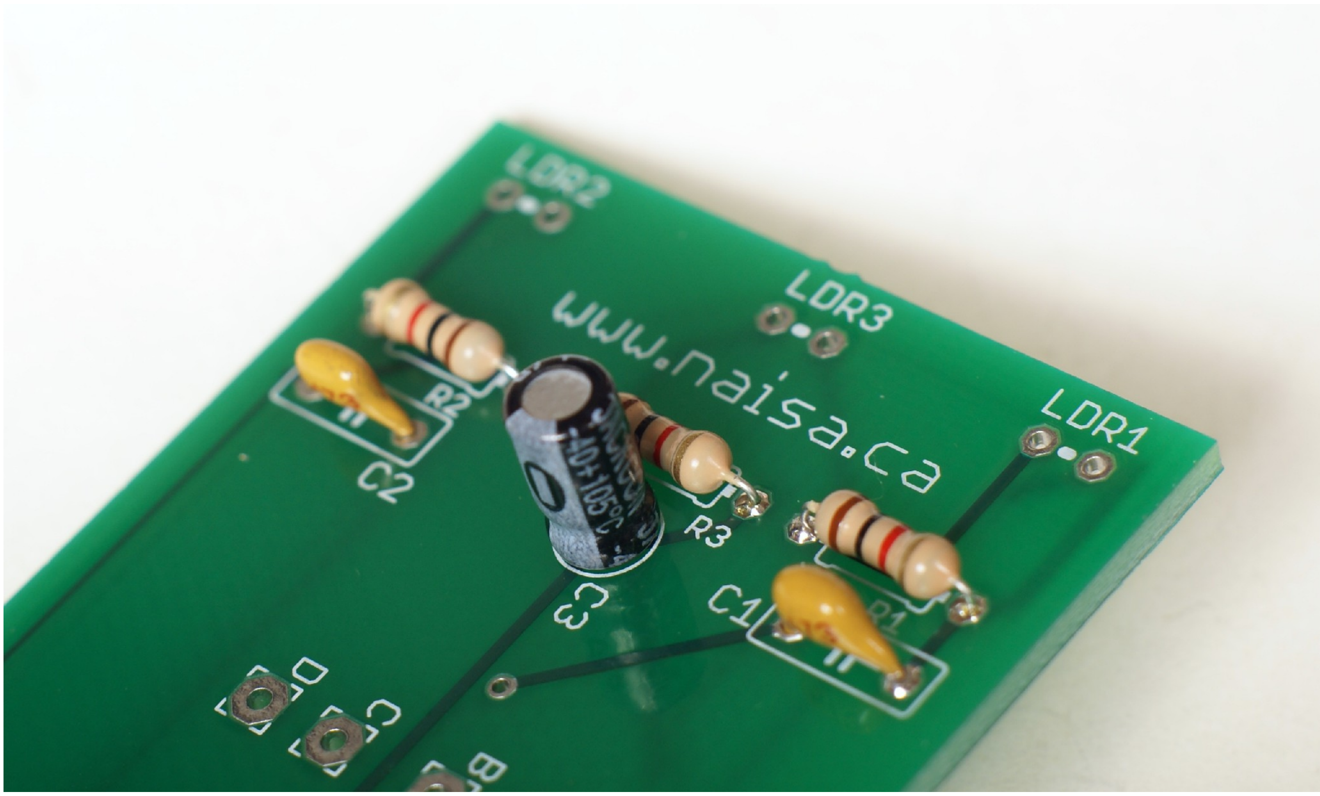


Install the capacitors

Next, you will mount the two 47nF capacitors in spots **C1** and **C2**.

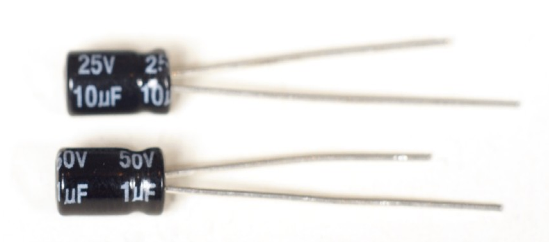
The capacitors should be marked “473”. Like the resistors, it doesn't matter which way they go in. After that, find the two 10µF and the two 1µF capacitors. Look at them carefully, and notice that one lead is longer than the other. The long lead is the positive lead and will go in the hole marked + on the circular

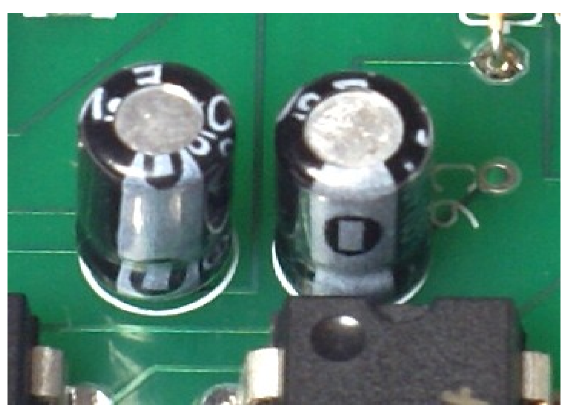
pattern on the board.
The shorter lead is the negative lead, and will go in the other hole. It lines up with the **- - - -** markings on the body of the capacitor.



Solder one of the 1µF capacitors in the spot marked **C3**. Make sure you have the correct value, and have it in the right way around! Solder the other 1µF capacitor in the spot marked **C6**.

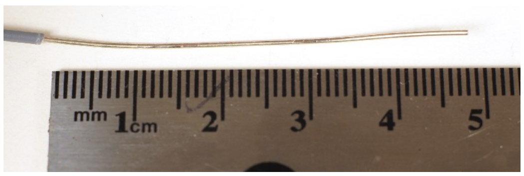
Then solder the two 10µF capacitors in the spots marked **C4** and **C5.** The electrolytic capacitors should sit flush with the surface of the board, like so:

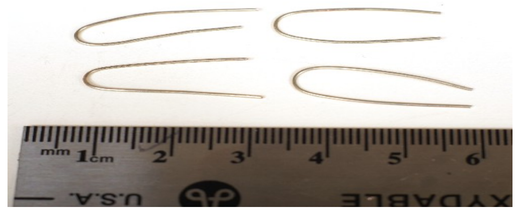




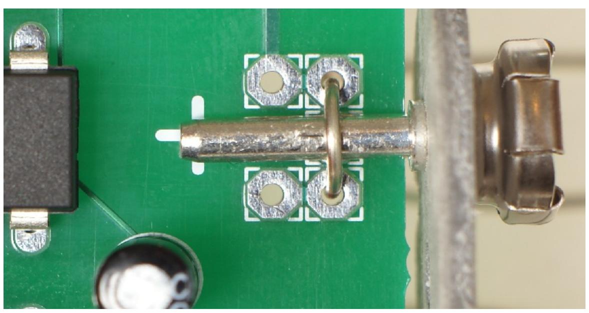
Install the battery clip

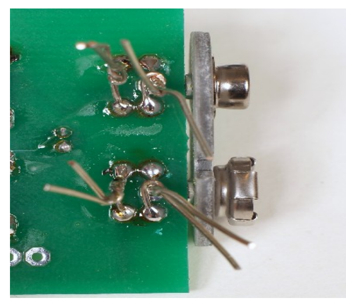
Now mount the battery clip. It's important to get this the right way around, and to solder it securely, and straight, because the NAISAtron will sit on top of the battery, and if the clip is crooked, it will look funny. Look at the clip, and notice that one terminal is bigger than the other. This one will go on the side marked +. You will solder it to the top of the board. If you have a helping hands tool, it will be very useful in this step to hold the clip while you secure it with wire. Cut and strip 4 pieces of solid 22 gauge wire, about 5cm long, and bend them into U shapes.



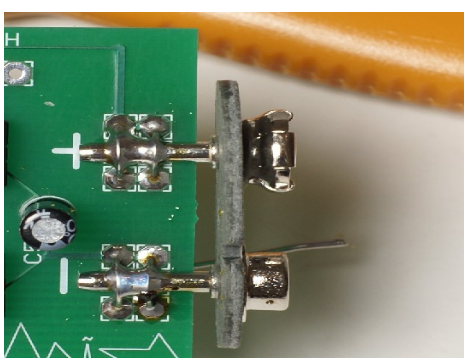


Secure the terminal firmly against the top of the board, twisting the wires at the back to hold it tight.





Solder the wires carefully on the bottom of the boards, and clip them, like you would with a resistor or capacitor. The clip should now be snugly in place. Make sure one more time that it's straight, and hold your soldering iron tip against one pin of the battery clip, and hold the solder at the point where the retaining wires touch the clip.
Don't melt the solder directly with the iron, let the clip get hot enough to melt it. At this point solder should flow freely around the pin and the wires, as shown. Allow it to cool slowly, don't blow on it, and keep the clip from wiggling until the solder hardens. Check once more for straightness (if it got crooked, reheat it, and gently hold it straight while the solder cools. This will be *much* more difficult if you wait until the second pin is done) then solder the other pin the same way. Make sure the wires are trimmed on the back, and that no wires or blobs of solder are shorting the + side to the – side. This connection has to be mechanically and electrically sound, so spend some extra time getting it right. Patience will pay off here.

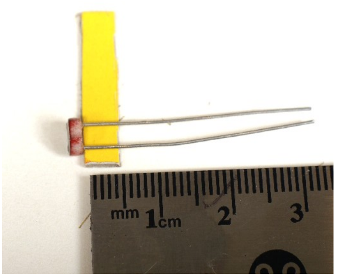


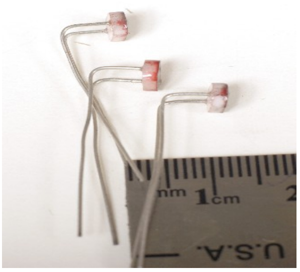
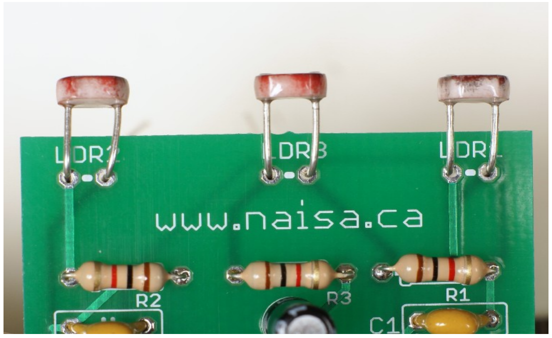
Install the switch

Next, install the switch, in the spot marked, you guessed it, **switch.** There's no front or back, it will go either way. It will fit more loosely than the other components. Don't bend the leads of the switch. You may want to hold it in place with a helping hands tool, or a small piece of masking tape while you solder one leg, then turn the board over to check that it's still straight before soldering the other two. It's easy to re-heat one connection and re-position the switch, it's much harder if all three are soldered.

Install the light-dependent resistors.

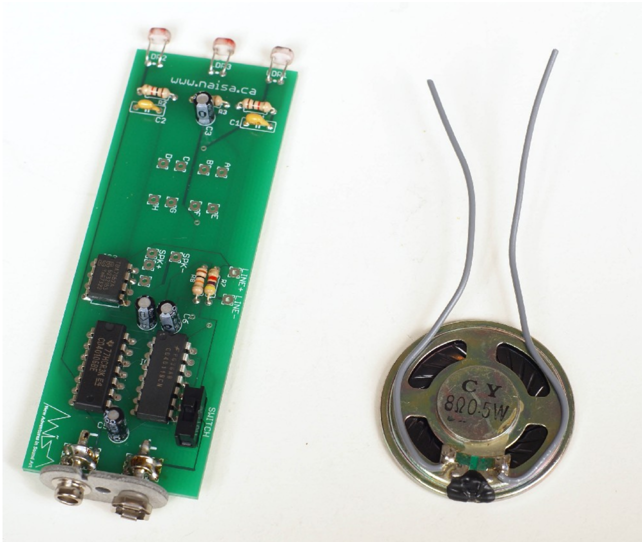
Now find the three light-dependent resistors. Make a right-angle bend, using the needlenose pliers, in the leads about 5mm down from the body. It helps to cut a small piece of cardboard or plastic to use as a template. You want the bend point exactly the same on all the leads, so that the LDRs will point straight up and look nice. Take some time to get them right- you can straighten and rebend the leads a few times without worrying about breaking them. Once you have it looking they way you want, solder **one** lead of each LDR, then adjust them again to make sure they are straight, then solder the other lead of each. Use the needlenose pliers to get the wires straight before you solder.

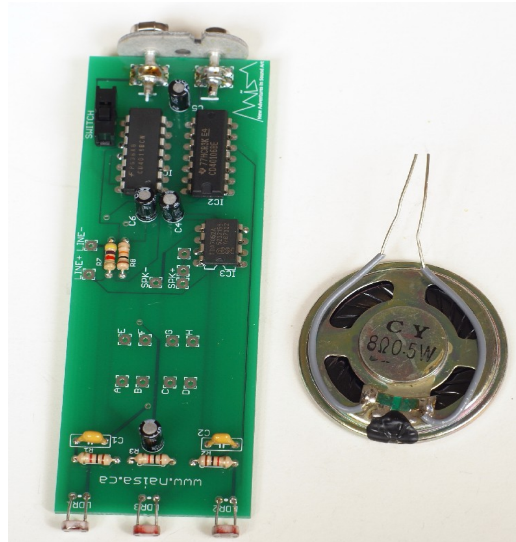


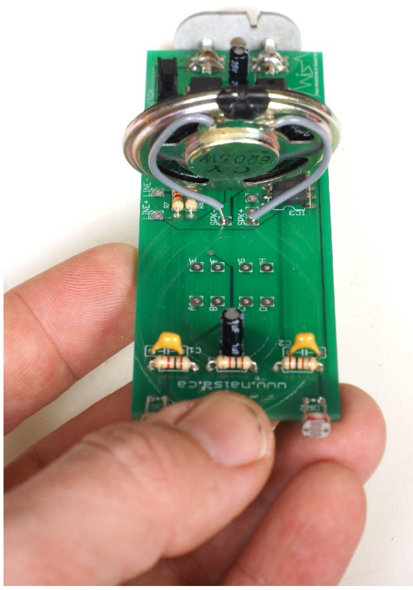
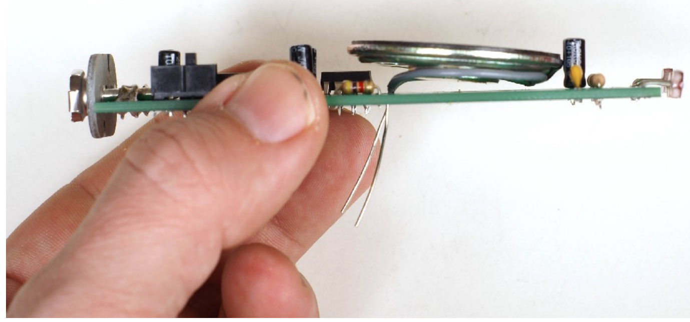
Install the speaker.

Cut two pieces of solid wire about 8cm long, and strip the ends about 3mm. Solder these to the speaker terminals. Note that they attach to the wing-shaped terminals marked + and **-**, not the solder points on the speaker where the delicate voice-coil wires attach. Form the wires in a horseshoe shape around the back of the speaker, as shown, then strip them back to near the edge of the speaker.





Fit the stripped ends into the holes marked **SPK+** and **SPK-** (these will wind up being the opposite of the markings on the speaker itself, don't worry about this)

Arrange the wires so that the speaker can lie almost flat against the board-you might have to strip a bit more, and bend the wires so that they lie concealed under the speaker. The solder terminals of the speaker will be near the electrolytic capacitor **C3**.Take some time, and make it look nice! Then solder

and clip the wires on the back of the board.
Affix the double-sided tape to the back of the speaker, and stick it firmly to the board, making sure that it is clear of the electrolytic capacitor **C3.**

That's it! You're done! Now test it!
Make sure the switch is in the down position,
and fit the battery clip gently to a 9V battery. It may be a bit stiff the first time, so make sure you don't strain the connection to the board. Flip the switch to the up position, and the NAISAtron should spring into life. If it doesn't, turn it off **immediately**, and proceed to the troubleshooting section.
Make sure you can hear the effect that light has on each of the 3 sensors. If one or more seems to not be responding, or if something sounds weird, go to the troubleshooting section.
If everything seems to be working the way you'd expect, take a moment to congratulate yourself, then take the rest of the day off to play with your NAIStron.

Troubleshooting

Oh no! What if it doesn't work? Don't despair. Most problems are fairly simple. Often a bad solder connection is to blame.

First, do visual inspection, and make sure nothing obvious is wrong, like a resistor in the wrong place,or a forgotten solder connection. Especially check that the battery connector is the right way around. Look at all your solder connections, and make sure they are shiny, not dull. If you are using lead-free solder, a dull appearance is normal. In either case you want your connections to appear smooth, not coarse and grainy.

Then, switch the power back on, and **carefully** feel the chips, making sure they are not hot. If a chip is hot, **immediately disconnect the battery.** This usually means the chip has been put in backwards, or something is shorted.

If you've put the chip in backwards, it will have to be removed using desoldering braid, and/or a solder sucker. This can be a challenging job. Prevention is the best medicine here.

Look for blobs of solder shorting adjacent pins together. This can often cause serious problems, but can easily be fixed with desoldering braid, or by simply re-heating the blob, then giving the board a sharp rap , solder-side down on a table, (one you don't mind getting a bit of hot solder on!) before the solder cools. Once you've cleared the blob, you may have to re-solder the appropriate pins.

Check the electrolytic capacitors- make sure they are in the right way.

Make sure the LDRs are properly soldered.

Make sure the speaker is correctly connected.

Glossary

AWG American Wire Gauge. A number that specifies the diameter of wire. Bigger numbers mean smaller wire. Most wire used in electronics is between 26 gauge (about the diameter of a sewing needle) and 22 gauge (about the diameter of paper-clip wire)

Capacitor A device which can store electrical energy. Capacitance is measured in **Farads,** but many capacitors have values in microfarads, (1/1000,000 Farad), usually abbreviated **µF**.

Chip See **IC.**

Electrolytic capacitor a **capacitor** which incorporates a liquid electrolyte as part of its construction. Electrolytic capacitors typically have higher values than smaller non-electrolytic capacitors.

Farad The unit of capacitance, named after Michael Faraday (1791-1867) Abbreviated **F.**

Flux An organic resin incorporated into the body of the **solder**, to assist the flow of molten metal. The flux is the source of the smoke produced when soldering.

IC Integrated Circuit. Also know as a **chip**, this is a device with many circuit elements, such as **resistors** and transistors, fabricated on a tiny wafer of silicon.

k prefix meaning kilo, or 1000.

k Ω Kilo Ohms, 1000 **ohms**. Pronounced "kay-ohms", or simply "kay".

Leads the wires protruding from the body of a components such as a **resistor**. Pronounced "leeds"

Legs a common name for the connection pins of an **IC chip**

LDR Light Dependent **Resistor**.

n prefix meaning nano, or 1/1,000,000,000

NAISA New Adventures In Sound Art. www.naisa.ca

nF **N**anofarad. 1/1,000,000,000th of a **Farad**. Until recently, values were often only specified in microfarads , not nanofarads, leading to some confusion. The 47nF **capacitors** in the kit are equivalent to .047µF.

Ohm The unit of resistance, named after Georg Ohm (1789-1854) Usually abbreviated by the Greek letter Omega: Ω

Pads The copper areas on the **circuit board** that components are **soldered** to.

Pins The metal connection points of an **IC chip**. Also known as "**legs**".

PCB Printed Circuit Board. The copper-plated fiberglass board that circuits are built on. Often called simply a "board" or "circuit board".

Polarity the direction of electrical flow in a circuit. Some components, like **resistors**, are not sensitive to polarity; they can be connected either way. Others, like **electrolytic capacitors**, have markings indicating polarity on them, and must be connected only one way. Polarity is indicated by + (read as "positive") and – (read as "negative")

Resistor A device which impedes the flow of electrons in a circuit. Resistors can be a fixed value, like the colour coded resistors in the kit, or variable, like the **light-dependent resistors** in the kit. Resistance is measured in **Ohms.**

Solder (noun) An alloy of two metals, usually lead and tin, but often silver and copper, used to make electrical connections. It usually contains a **flux** which is a resinous organic material, which serves to improve the flow of the molten solder.

Solder (verb) To make electrical connections using solder. Soldering is distinct from welding in that the parts being joined do not themselves melt. The “l” in solder is often silent in North America, particularly in the USA.

Speaker A device to convert electrical energy into sound.

Volt The unit of electrical potential, named after Alessandro Volta (1745-1827)

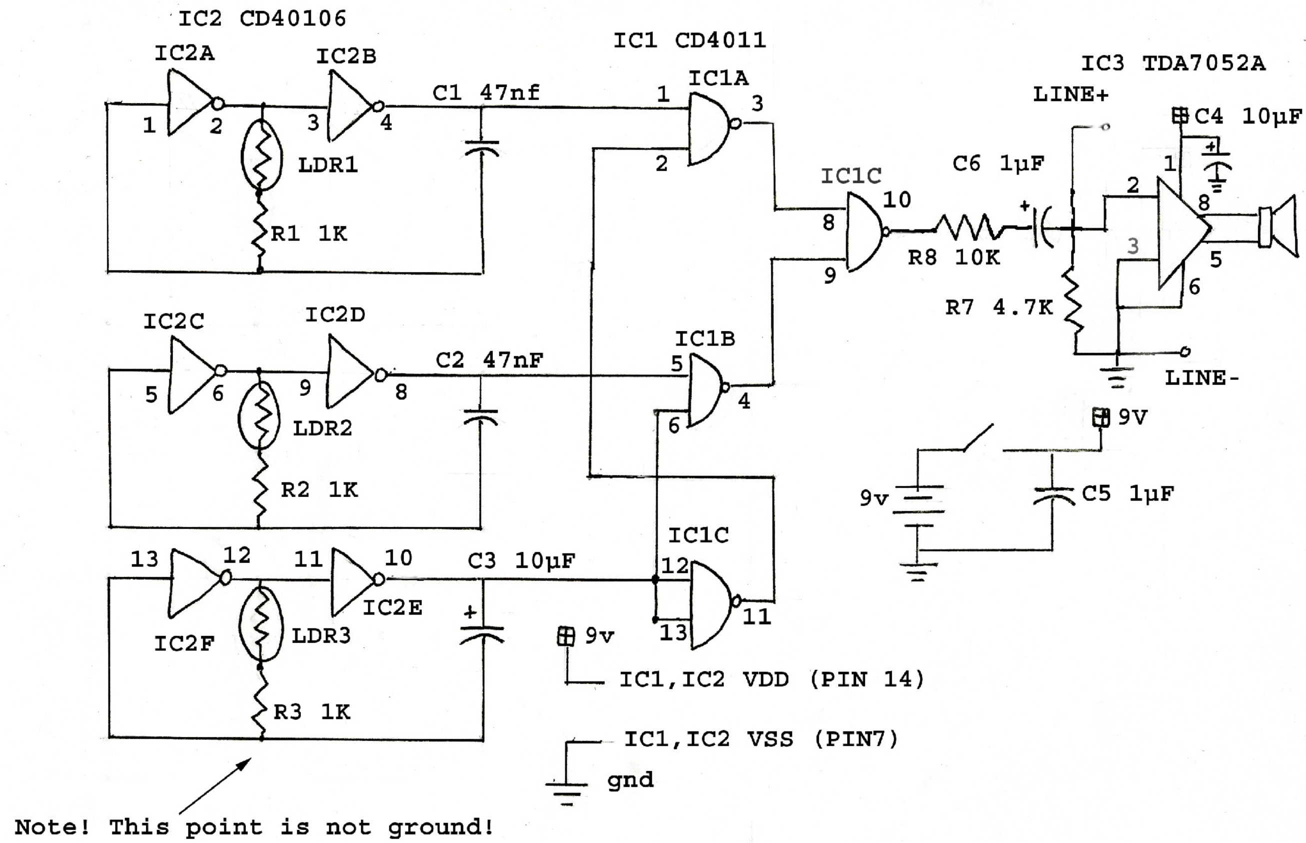
Ω The Greek letter “Omega”, used as a symbol for “ohms”

µ The Greek letter “Mu”, used here as a prefix to mean “micro”, or 1/1,000,000

µF Microfarad. 1/1,000,000th of a Farad. Pronounced as “microfarad”. Many capacitors have values specified in microfarads.

The technical stuff.

Schematic:



How it works:

(Don't worry-you don't need to know this to build the kit!)

The NAISAtron consists of 3 astable multivibrators, using the hex Schmitt Trigger , IC2.

LDR1, R1, and C1 set the frequency of the first astable, and an identical circuit is formed around LDR2, R2, and C2. The frequency is approximately1/((LDR1+R1)C1). LDR1 ranges from about 300 ohms in bright sunlight, to several hundred thousand ohms in darkness.

The circuit with LDR3, C3 and R3 is similar, but has a much lower frequency than the other two astables, by a factor of slightly more than 200.

IC1 is a quad NAND gate and is used used to gate the two high-frequency oscillators using the output of the low-frequency oscillator.

The low-frequency output at IC2E is sent to an inverter formed by IC1C, and the inverted signal goes to pin 2 of IC1A, and the non-inverted signal goes to pin6 of IC1B.

If we call the high frequency astables **A** and **B**, and the low frequency astable **L**,

then the output at pin 10 of IC1C is

$\overline{\overline{A\overline{L}}\ \overline{BL}}$ which reduces to $(A\overline{L}) + (BL)$ by Demorgan's Theorem.

So when L is low, the output of **A** is sent to the speaker, and when **L** is high, the output of **B** is sent to the speaker, giving an alternating effect.

C6 decouples the signal, which is sent to the amplifier, IC3.