Solar Sound Module

http://www.cla.purdue.edu/vpa/etb/
Shannon McMullen | Fabian Winkler

Based on a workshop of the same name by Ralf Schreiber
See: http://www.ralfschreiber.com/solarsound/solarsound.html

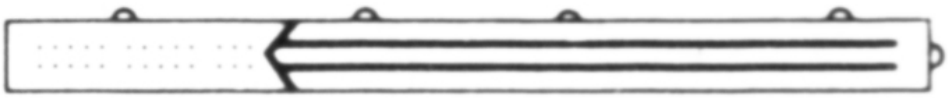
Required parts/supplies for this workshop:

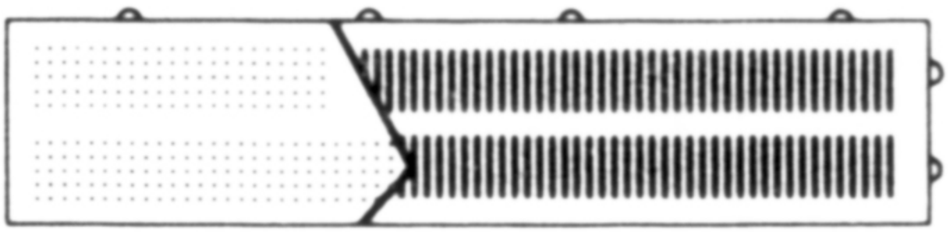
Description	**Jameco part # (unless otherwise noted)**
Hex Inverter IC 74HC14	PN 45364
solar power film SP3-37, 3.0V 22mA	PN 227985
solderless breadboard	PN 20601
resistors, from 100Ω – 100k	
capacitors, from 1 – 47μF	
wires (solid core)	PN 36920
multimeter (look in the cabinets in the Mac lab in STEW and FPRD 204)	PN 355207
wire cutter (look in the cabinets in the Mac lab in STEW and FPRD 204)	PN 146712
Piezo speaker (look for ones that are rated at close to 3V)	Radioshack 273-060

How does a breadboard work?

Breadboards are useful solderless prototyping boards that allow you to test out circuits quickly. In general it is a good idea to build every circuit on a breadboard first before you even think about soldering the parts together. Thus, it is important to understand how a breadboard works.

The type of breadboard we are going to use in the following workshops is similar to the one displayed below. It consists of two long rows on each side (called bus rows) and many holes in the center, divided by a gap. Holes in the bus rows are connected horizontally, holes in the center are connected vertically (in columns). The detail below shows this difference – the horizontal line shows one of the bus rows, the two vertical lines emphasize two columns in the center. Physically, the holes underneath each of these lines are connected with a metal strip.





The bus rows, usually 2 on each side, are reserved for positive power and ground. The holes in the center columns are for components. The divider between the columns will be very useful when we start working with ICs (Integrated Circuits). It assures that each pin of the IC has its own column for other parts to be connected to it.

Preparing the solar cell (from the PowerFilm datasheet)

The solar cell's purpose is to make the electronic circuit sustainable, i.e. provide it with power from the sun, without the need of any batteries or power cords. We are using a solar module called PowerFilm which is paper thin, flexible and extremely durable. You can use any kind of solar module as long as its power output is around 3V.

The positive end of the solar module is shown in the diagram above. The recommended connector wire size is a minimum size of 24 gauge. As an extra measure, connect the solar module to a digital multimeter for polarity (+,–) identification.

Soldering
Use the hot tip of the soldering iron to melt through the clean coating of the copper tape. Be careful not to burn through more than just the thin clear coating. Burning too deeply can damage the solar module. Although not necessary, it is possible to remove a small piece of the clear coating with a sharp knife prior to soldering to the copper tape. Good contact can be made by melting and depositing a dot of solder to the exposed copper tape. Use a low temperature soldering iron adjusted to about 600 to 650 degrees (F). It is also acceptable to solder directly to the copper tape, without using a solder dot.

Put a blob of hot glue on each exposed solder joint after soldering the wires to the solar film, it reinforces the connection and helps them to stay longer on the copper contacts.

Solar Sound Module

From Ralf Schreiber's tutorial
(http://www.ralfschreiber.com/solarsound/solarsound.html):

solarsoundmodule
I developed the solarsoundmodule in 1996. It's a simple analogue circuit an attached piezo speaker and a small solarpanel. The module generates tiny and various sound pattern which sometimes reminds you to birds or insect sounds. The kind of sound and the intensity depends on the amount of light that touches the surface. Every module is special and unique and it's impossible to build exactly the same module twice. The solarsoundmodule starts in the morning with the first sunbeams and stops in the evening. It will work several decades. The circuit provides the basis for the "living particles" installations and workshops.

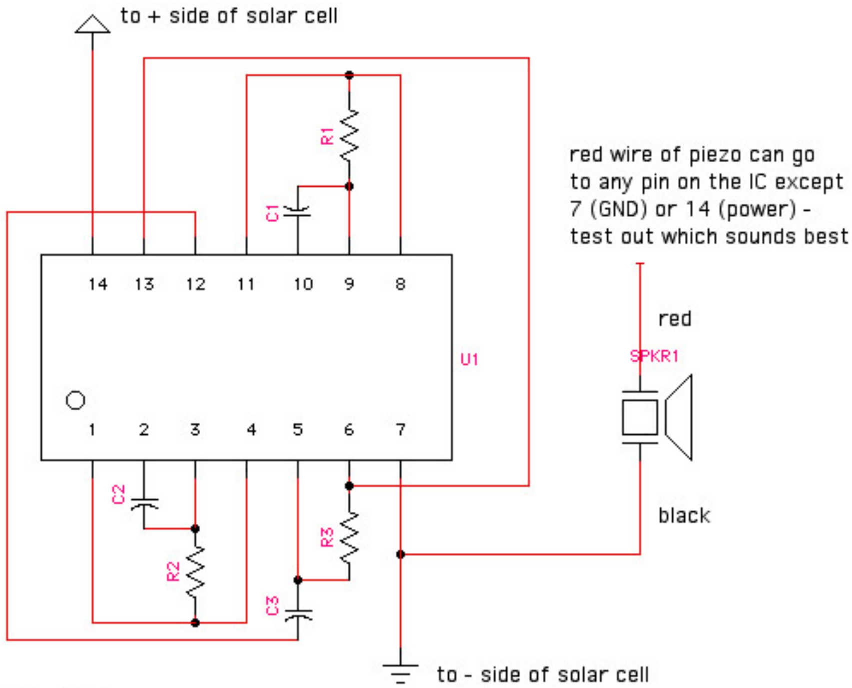
Circuit
A good explanation of what is going on inside the circuit from the group ChromaticField (http://www.sciss.de/chromaticfield): "The core element of the circuit is a logic CMOS chip. We'll here present the circuit used by Ralf Schreiber which is very suitable for workshops because it is extremely simple. The CMOS family contains all sorts of logic elements, like AND, OR, NOR gates etc. The 74HC14 used in this diagram is actually an ensemble of six identical parts which are called Schmitt-Triggers. A trigger compares an input voltage to a control voltage which is called the threshold; if the input voltage is greater than the threshold, current will flow from input to output, if the input voltage is too low, current will be blocked.

The Schmitt-Trigger is an inverting trigger. That means if the input voltage falls below the threshold, the output will have high voltage and vice versa. This allows the creation of feedback loops. Imagine the trigger switches the output voltage to low and the output is connected to another input. So the successive comparator stage recognizes input voltage has dropped to low and will set its output voltage to high. If the circuit is connected in a loop, the switching of the voltages will go on forever. Naturally, triggers don't switch infinitely fast but require some time. If the frequency of the feedback loops matches the range of audible frequencies, roughly 16 Hertz (cycles per second) to 18.000 Hertz, the circuit becomes a sound generator.

Capacitors and resistors are so called passive elements. As opposed to the IC chip they don't require powering to work. If you use a metaphor and think of electric current as water current, a capacitor is a sort of cup that can save a certain amount of charge. When the voltage changes, the saved charge can flow back into the circuit.

Likewise, a resistor obstructs the current flow. Put in a series, resistors can divide the voltage between two points of the circuit. Combining capacitors and resistors in a certain way results in an oscillation that has a resonance frequency. The circuit shown here creates three oscillators, each using two triggers in a feedback loop."

In contrast to Ralf Schreiber's tutorial, we will build the solar sound module on a solderless breadboard. This allows us build the circuit faster and to experiment more with different values for the electronic components. On the next page you find a diagram of the circuit we are building.

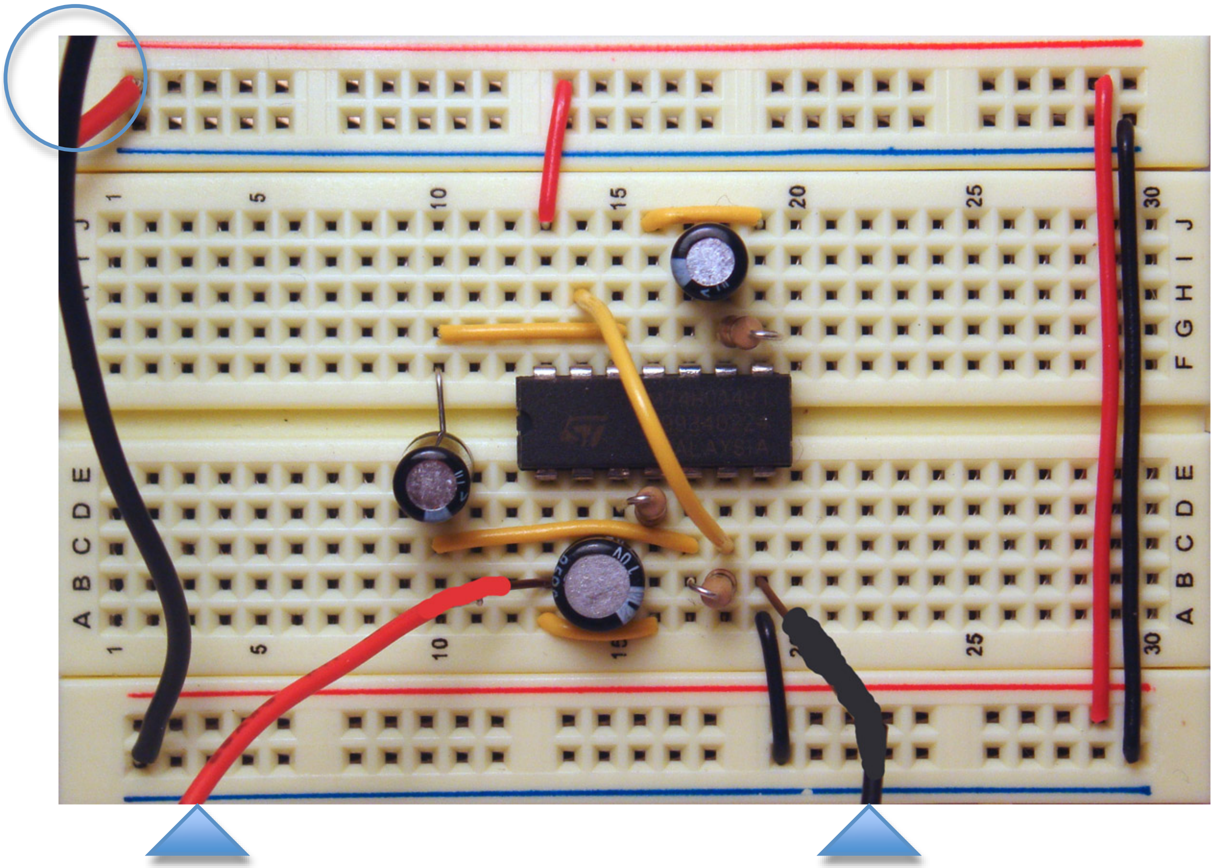


R1, 2, 3 - resistors, 100Ω - 100k
C1, 2, 3 - capacitors, 1μF - 47μF
U1 - IC 75HC14
SPKR1 - piezo speaker, Radioshack 273-060
power from solar cell (around 3V)

You have to experiment with different values for your capacitors and resistors to find nice sounds. I found a good starter combination for my circuit with: R1 = 10k, R2 = 10k, R3 = 270Ω, C1 = 10μ, C2 = 10μ, C3 = 10μ

On the following page are some pictures of how your circuit should look like (with the exception of different values for the resistors and capacitors).

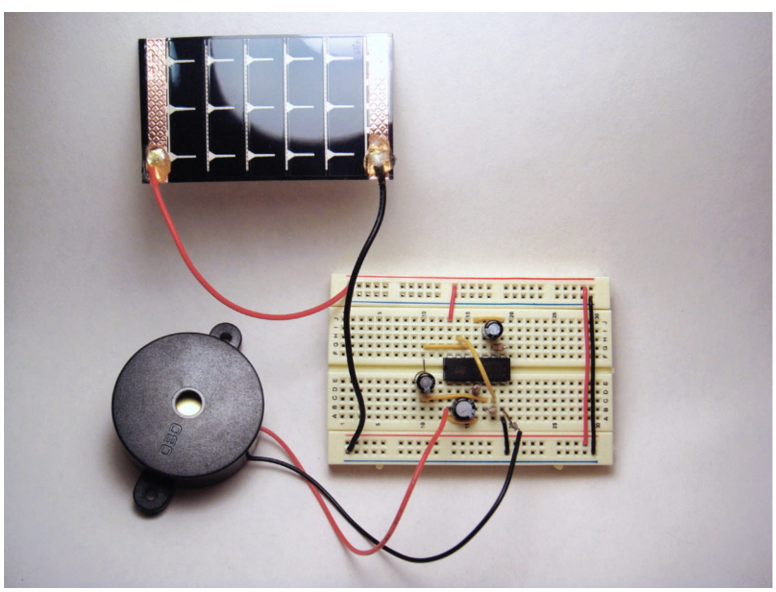
red and black wire from solar cell
going into breadboard’s power and GND bus



to piezo (red wire)

to piezo (black wire)

Below is a picture of the complete circuit (incl. piezo speaker and solar cell):



If you do not hear a chirping right away, go outside and expose the solar cell to the sun or hold it very close to an incandescent light bulb. If you still do not hear anything you might have the wrong type of piezo (not suitable for 3V output), the wrong type of solar cell (cannot produce at least 2.5V) or you have made a mistake in your circuit. In this case, go back to page 4 and follow all the connections (sometimes checking the ones you have followed with a pencil is helpful).

Have fun!

Further resources:
http://www.sciss.de/chromaticfield/texts/modules.html
http://www.beam-wiki.org/wiki/Main_Page