

# how to build a light-controlled mixer

go to the dark side and start controlling sound!

BY ROB CRUICKSHANK

PHOTOGRAPHY BY ADAM COISH



**G**ESTURAL CONTROL IS a hot topic these days. A bit of searching on the Internet will turn up all sorts of projects that can turn hand waving into sound, using accelerometers, cameras, or Microsoft's Kinect controller. But did you know that for only a few dollars you can make a hands-free controller that uses no computers, chips, or even batteries? It's a simple passive circuit, based on light-dependent resistors, that will mix two audio signals, based on the amount of light falling on its sensors. Not so hi-tech, but definitely gestural.

Our circuit is a simple passive mixer—a primitive ancestor of the larger, more sophisticated mixers you may be familiar with, used in recording and PA applications. Instead of knobs or sliders, however, our mixer will use four photocells. These are components that change their resistance with the amount of light falling on them. Our circuit will be wired so that increasing the light on the sensor will decrease the amount of audio passing through the circuit. You might want to think of this as a dark-controlled mixer.

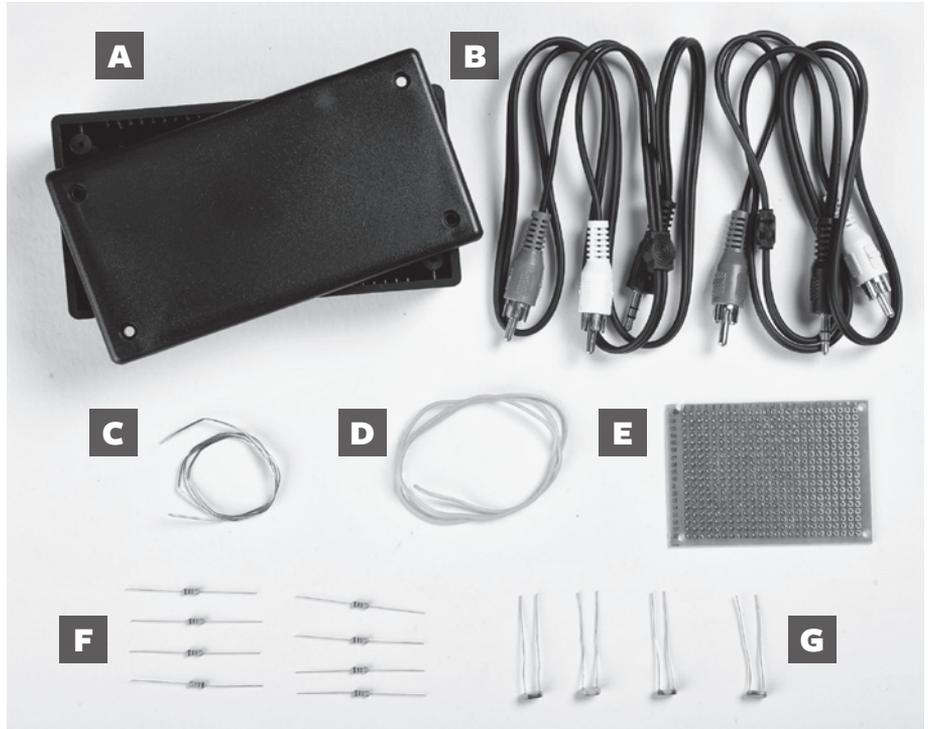
This circuit was inspired by the Lowell Cross' design for the chessboard used in the 1968 performance *Reunion*, featuring John Cage and Marcel Duchamp. For more on that, see Cross' article "Reunion: John Cage, Marcel Duchamp, Electronic Music and Chess" in the December 1999 issue of the *Leonardo Music Journal*.

We'll show the mixer as mixing two stereo (two-channel) inputs down to one stereo output, but you can also build it to mix four mono sources to one mono output.

# set up

## materials

- [A]** 1 small plastic project box (available from any electronics supplier) in which to house the mixer
- [B]** 2 audio cables, each with a 3.5 mm stereo miniplug on one end, and a pair of male RCA connectors on the other end
- [C]** Rosin-core electronics solder (consider using the lead-free variety)
- [D]** Insulated hookup wire, 22 gauge, solid-core (you'll need about a metre)
- [E]** 1 piece of circuit board sized to fit the project box, **[A]**
- [F]** 8 10k-ohm resistors coded with three bars—brown, black, and orange
- [G]** 4 matching light-dependent resistors (LDRs), also known as photocells, photo resistors, or cadmium sulphide (CdS) cells



## tools (NOT PICTURED)

Soldering iron with small tip, 40 watts or less  
Small wire cutters  
Wire strippers suitable for wire gauges from 26 to 20  
Needle-nose pliers  
Safety glasses or goggles  
Indelible-ink marker

Masking tape  
Ruler marked in inches and millimetres  
Drill, with a series of drill bits 1/16 to 1/4 inch  
Glue gun with glue sticks  
Small screwdriver

## WHAT YOU NEED TO KNOW BEFORE BEGINNING

### how to solder

There is a good collection of soldering resources on the Website of Limor Fried, an engineer and artist who makes and sells electronic kits, <[www.ladyada.net/learn/soldering/thm.html](http://www.ladyada.net/learn/soldering/thm.html)>. Also see <[www.youtube.com/watch?v=l\\_NU2ruzyc4&feature=player\\_embedded](http://www.youtube.com/watch?v=l_NU2ruzyc4&feature=player_embedded)>.

### how to work with a circuit board

A page specifically about circuit-board techniques, as used in this project, can be found at <[itp.nyu.edu/physcomp/Tutorials/SolderingAPerfBoard](http://itp.nyu.edu/physcomp/Tutorials/SolderingAPerfBoard)>. An excellent book for electronics beginners is *Make: Electronics*, from O'Reilly media, <[oreilly.com/catalog/9780596153755](http://oreilly.com/catalog/9780596153755)>. ISBN: 0596153750

## MATERIALS SOURCES

Light-dependent resistors are sometimes hard to find. Look for ones with a light resistance in the low hundreds of ohms, and a dark resistance of at least several-hundred-kilo ohms. The low value for the light resistance is the most critical value to look for. We used part number OPTRE-000007 from Creatron electronics, <[www.creatroninc.com](http://www.creatroninc.com)>. Part number CDS from Solarbotics, <[www.solarbotics.com](http://www.solarbotics.com)>, would also work well.

If you live in a large city, you will have more options for buying parts and tools. Dedicated electronics retailers:

Active Tech in major cities across Canada, <[www.active123.com](http://www.active123.com)>  
Creatron in Toronto, <[www.creatroninc.com](http://www.creatroninc.com)>  
Addison in Montreal, <[www.addison-electronique.com](http://www.addison-electronique.com)>

These are excellent online sources:  
Digi-Key, <[www.digikey.com](http://www.digikey.com)>  
Mouser Electronics, <[www.mouser.com](http://www.mouser.com)>

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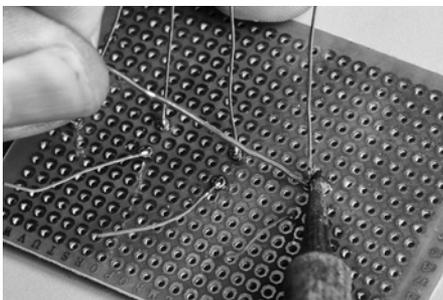
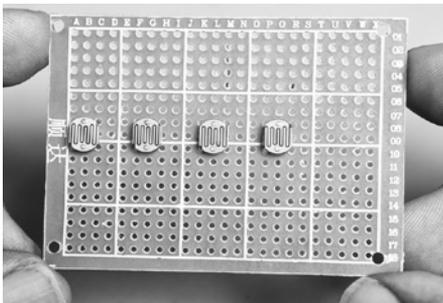
# make it

**time required:** one hour **complexity:** moderate **cost:** five dollars

**what you need to know:** how to solder, plus basic electronic construction techniques—and you need to be comfortable using a power drill and a glue gun

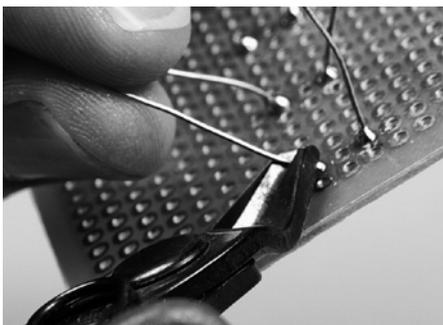
## 1 wire up the circuit

**1a.** Install the LDRs on the circuit board, arranging them horizontally so that the leads are oriented vertically, and space them out so that you can control them individually. **NOTE:** The LDRs do not have polarity, and so can be installed either way.

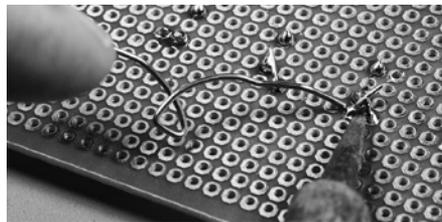
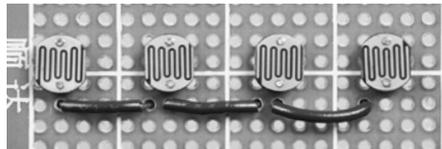


**NOTE:** Because you will be mounting the project in a box, you need to count the number of holes in the circuit board between the LDRs in order to determine the spacing of the holes you'll drill into the box. The holes in the board are 0.1 inch apart, so it is best to leave four holes between each LDR, and then space the holes in the project box half an inch apart.

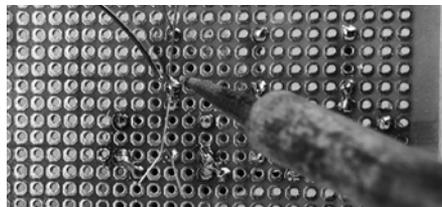
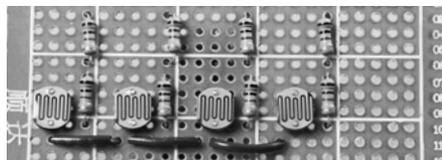
**1b.** Use the wire cutters to clip the leads close to the solder.



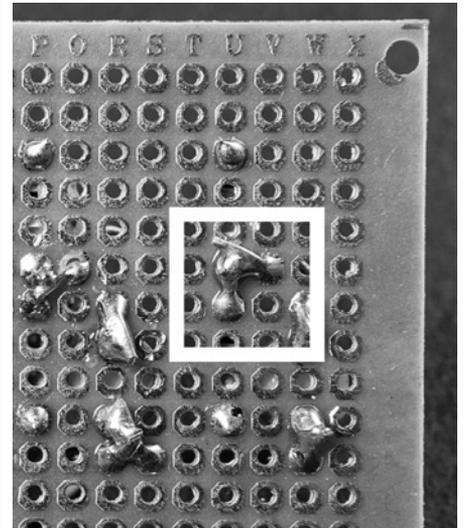
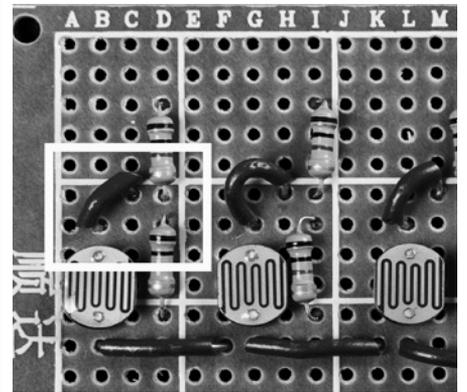
**1c.** Use hookup wire to solder connections between the lower leads of all the LDRs, as shown. **NOTE:** This will become the common ground point of the circuit.



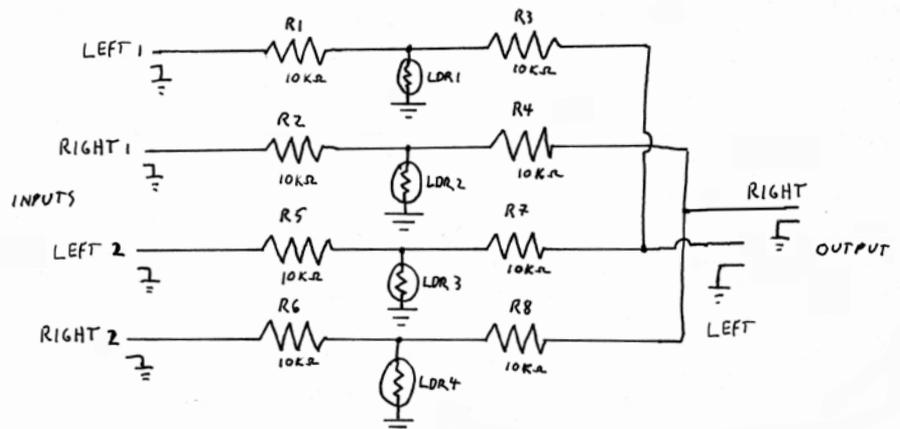
**1d.** Solder a pair of 10k-ohm resistors beside each LDR, as shown.



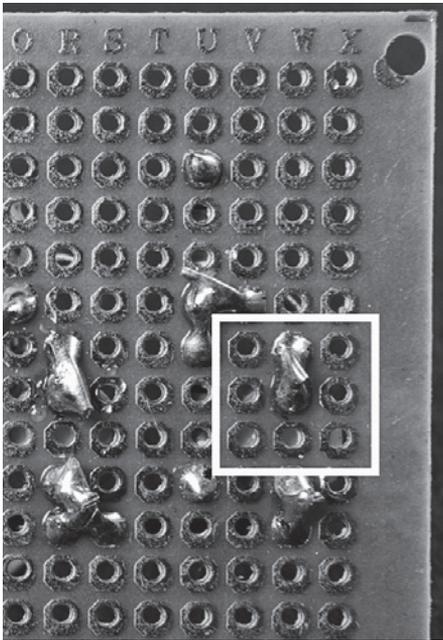
**1e.** Solder a connection between the adjacent leads of one set of paired resistors.



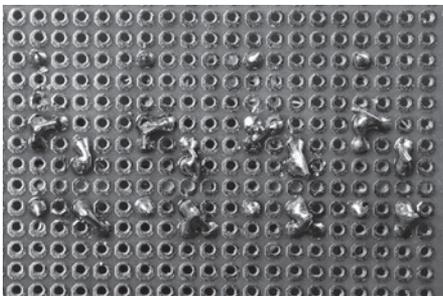
## 2-TO-1 LIGHT-CONTROLLED MIXER CIRCUIT SCHEMATIC



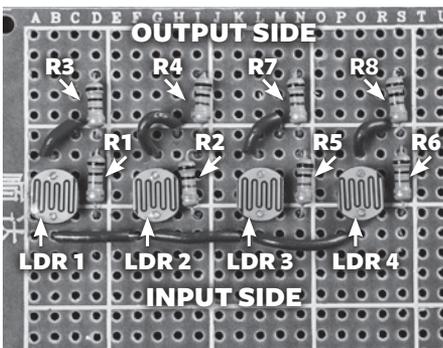
**1f.** Use the free end of the hookup wire to solder the connection made in 1e to the free lead of its adjacent LDR.



**1g.** Repeat steps 1e and 1f with each set of paired resistors and each LDR.



**NOTE:** Looking at the board, consider the LDRs to be numbered left to right, 1, 2, 3, and 4.

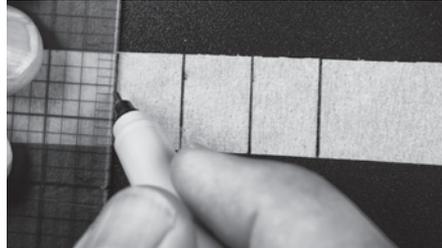


## 2 prepare the mixer box

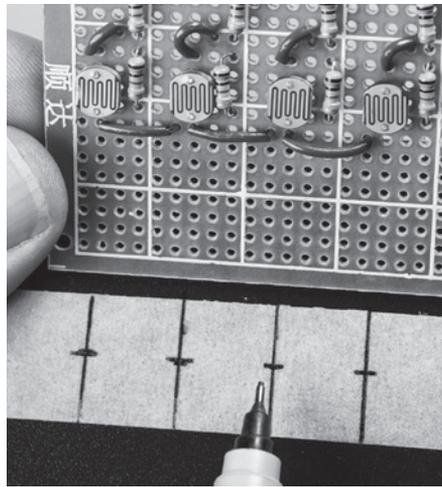
**2a.** Mark on the project box the placement of the holes for the light sensors.

**i.** Place a piece of masking tape lengthwise down the centre of the project box lid, on the inside of which you will be mounting the mixer.

**ii.** Use the placement of the centre of each LDR on the circuit board and the measurements made in step 1a to locate the correct position of each LDR hole on the project box that will become your mixer box.



**iii.** Use an indelible marker to indicate the position of each hole.

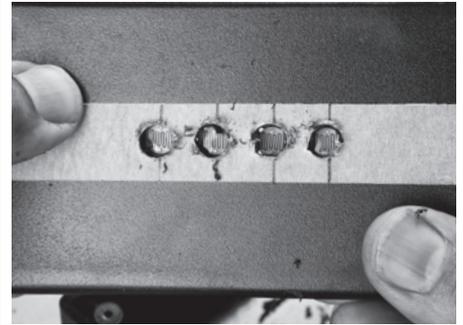


**2b.** Make the holes in the project box at the point where the light sensors will go.

**i.** Use the 1/16-inch drill bit to drill pilot holes in the project box at all the marked LDR locations.



**ii.** Gradually increase the size of your drill bit until the diameter of each hole is slightly larger than the diameter of each photocell. **NOTE:** Don't be tempted to go straight to the largest size, because the drill bit may grab the plastic, ruining the hole, and possibly causing injury.

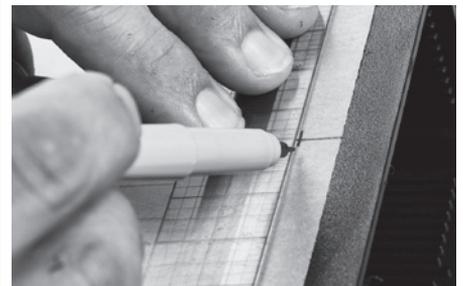


**iii.** Remove the masking tape.

**2c.** Mark on the project box the placement of the hole for the audio output.

**i.** Place a piece of masking tape along the centre line on the long edges of the project box's side.

**ii.** Use an indelible marker and ruler to indicate the centre on both sides of the project box.

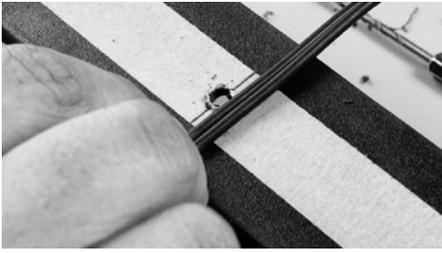


**2d.** Make the hole in the project box for the audio output.

**i.** Use the 1/16-inch drill bit to drill a pilot hole on the project box's side for the output cable.



**ii.** Gradually increase the size of your drill bit until the diameter of the hole is the same as the diameter of the output cable.



**2e.** Follow the drilling procedure in 2d to make two holes on the opposite side of the project box, each hole to be one half inch on either side of the centre.



## 3 connect the audio inputs and output to the circuit

**3a.** Use the wire cutters to cut the two audio cables in half.

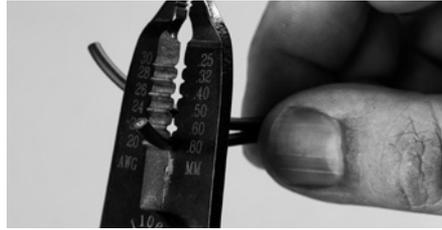


**NOTE:** The two ends with 3.5 mm plugs will connect to the circuit's inputs, and one of the ends with a pair of RCA connectors will connect to the output side. Save the other one for future projects.



**3b.** Strip and tin the wire ends of the audio cables.

**i.** Use wire strippers to remove 2 cm of the outer jacket on the free end of one of the audio cables.



**ii.** Twist together the shield wires.



**iii.** Use solder to tin the exposed shield wires.



**iv.** Use wire strippers to remove 5 mm of insulation from the centre audio conductor.  
**NOTE:** This is usually a fine 28-gauge conductor, so take care not to cut it.



## GLOSSARY

**Cadmium Sulphide.** A chemical compound used in making light-dependent resistors.

**Circuit Board.** A board, usually fiberglass, perforated with holes to mount components in.

**Ground.** The common point in a circuit, where all signals return.

**Kilo.** A prefix meaning 1000. One kilo ohm, usually written 1kohm, or 1 k $\Omega$ , is 1000 ohms.

**Leads.** Pronounced leeds. The wires protruding from an electronic component such as a resistor.

**Light-dependent Resistor.** A resistor which changes its resistance with the amount of light falling on it.

**Miniplug.** A 1/8-inch (3.5 mm) audio connector most commonly used with portable headphones.

**Mixer.** A device for combining audio signals.

**Ohm.** A unit of electrical resistance, named after Georg Ohm.

$\Omega$ . The Greek letter omega, used as a symbol for ohms.

**Photocell.** A light-sensitive electronic component, usually a light-dependent resistor.

**Project Box.** An inexpensive plastic enclosure designed to hold an electronic circuit.

**RCA Connector.** A small connector, also known as a phono connector, invented by the Radio Corporation of America, and often used in home audio.

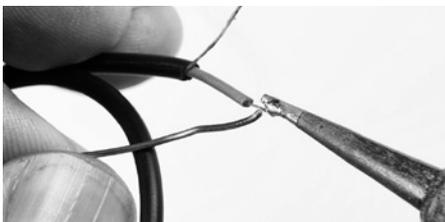
**Resistor.** A device that limits electrical current.

**Shield.** The outer wires in an audio cable, which surround the centre conductor, and are connected to the common ground.

**Tin.** The action of coating a conductor (usually copper) with solder to facilitate ease in soldering. Note that hookup wire is often pre-tinned.

**Wire Gauge.** A system for specifying wire sizes. Smaller diameter wires have larger gauge numbers.

**v.** Use solder to tin the centre conductor, making sure not to use too much heat, which can melt the insulation.



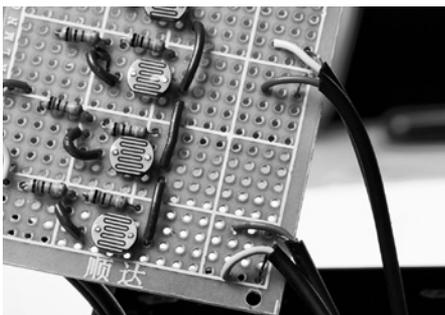
**vi.** Repeat steps i to v five times with the remaining audio cables.



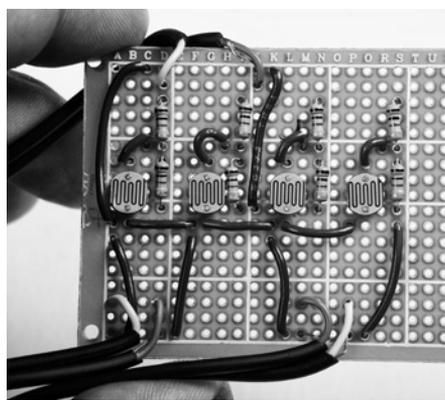
**3c.** Feed the cut ends of the input cables and output cables through the holes made for them. **NOTE:** Be aware that once the cables are soldered to the board, you will not be able to separate the circuit from the box without unsoldering the cables.



**3d.** Solder each of the audio cables to the circuit board—audio inputs on one side of the circuit and the audio output on the other side of the circuit. **NOTE:** The centre conductor and the shield should be soldered into holes in the board with one or two holes between them, taking care that they cannot short together if the cable is flexed.



**3e.** Use hookup wire to connect each of the audio cables' shield wires to the common ground point created in step 1c.



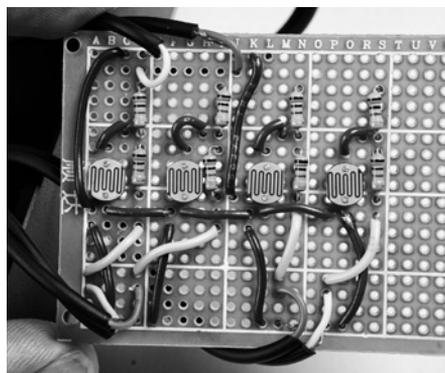
**3f.** Wire up the input side of the circuit. **NOTE:** Please refer to labelled image on pg 50, step 1g.

**i.** Use hookup wire to make a connection between the left audio channel of the first audio input cable to the free end of the resistor associated with LDR1: R1.

**ii.** Use hookup wire to make a connection between the right audio channel (usually indicated by a red conductor) of the first audio input cable to the free end of the resistor associated with LDR2: R4.

**iii.** Use hookup wire to make a connection between the left audio channel of the second audio input cable to the free end of the resistor associated with LDR3: R5.

**iv.** Use hookup wire to make a connection between the right audio channel of the second audio input cable to the free end of the resistor associated with LDR4: R6.



**3g.** Wire up the output side of the circuit. **NOTE:** Please refer to labelled image on pg 50, step 1g.

**i.** Use hookup wire to connect the free ends of the output resistors R4 and R8. **NOTE:** This connection allows the individual right signals to be mixed down to the master right channel.

## TROUBLESHOOTING

### 1. If a channel is missing entirely

- Check the connections between the audio cables and resistors.
- Check both input and output connections.
- Check the connection between resistors on each channel, e.g., the connection between R1 and R3.
- Make sure that there are no electrical short circuits between the centre conductor and the shield.

### 2. If the channel is present, but does not drop out when light hits the LDR

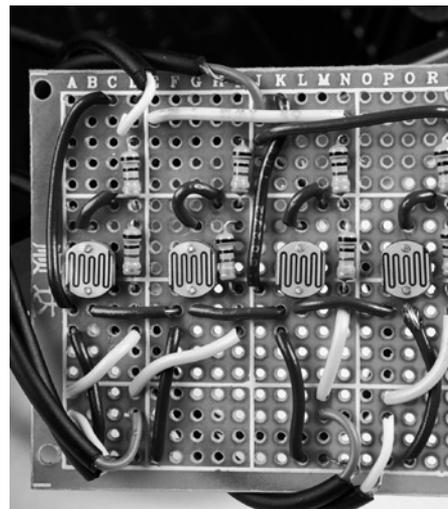
- Check the connections between the resistors and the LDR.
- Check the connections between the LDR and the common ground.

**NOTE:** This is not a perfect mixer. You will always get a little bleed-through between channels, even in bright light, and the balance between channels may not be accurate.

**ii.** Use hookup wire to make a connection between the right audio channel of the audio output cable to the junction of resistors R4 and R8.

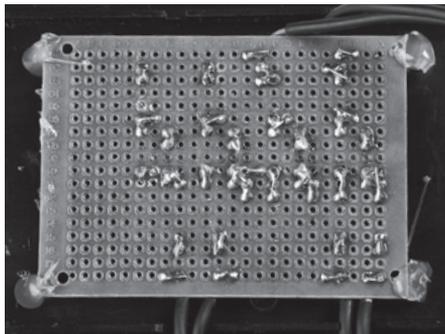
**iii.** Use hookup wire to connect the free ends of the output resistors R3 and R7. **NOTE:** This connection allows the individual left signals to be mixed down to the master left channel.

**iv.** Use hookup wire to make a connection between the left audio channel of the audio output cable to the junction of resistors R3 and R7.



## 4 mount the circuit in the project box

**4a.** Use hot glue to secure the circuit board to the top side of the enclosure in such a way that the LDRs line up with the appropriate holes.



**4b.** Use hot glue to secure the cables in place, so that they don't get yanked out of the board.



## 5 testing

The circuit works best in bright light, such as sunlight. A battery-powered flashlight works well. Fluorescent lights and AC-powered LED lights might introduce objectionable hum into the circuit.

**5a.** Connect the 3.5 mm stereo plugs to two audio sources, such as MP3 players or laptop computers.

**5b.** Connect the RCA plugs to the left and right inputs of an amplifier.

**5c.** Cover each LDR with a small opaque piece of cardboard. You should hear the audio from both sources, mixed together.

**5d.** Remove the piece of cardboard from one of the LDRs. Expose that LDR to a bright light, such as an LED flashlight. You should hear the corresponding audio channel drop out of the audio mix. Repeat with the other LDRs, listening for the other corresponding channels to drop out of the audio mix.

## use it

There are many ways to use the mixer. Some suggestions are:

**Use light to fade** between two stereo sources.

**Use four completely separate** audio signals in, and use a flashlight to make a real-time composition.

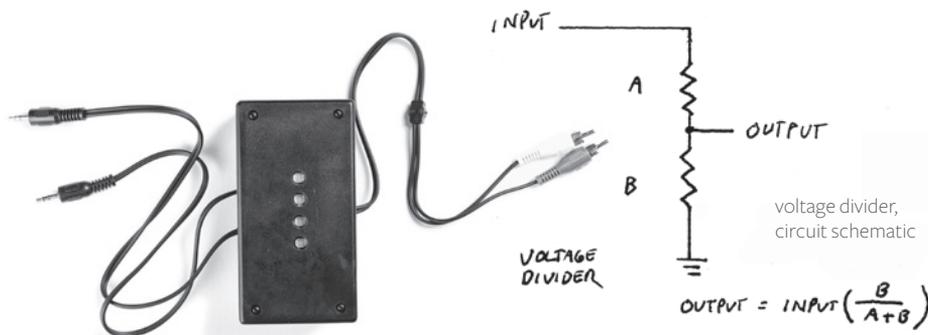
**Make an audio installation** that adjusts audio with the amount of daylight falling on the sensors.

**Because the mixer is completely passive,** it will work as well backwards as forwards! Try routing a stereo source to two pairs of powered speakers (you may need some audio adaptors for this).

**ROB CRUICKSHANK** is a Toronto-based multidisciplinary artist.



## how it works



**A MIXER IS** a special case of a basic circuit called a voltage divider. A voltage divider takes a voltage source (in our case, an audio signal) and splits it up between two resistors. If one resistor has a higher resistance (measured in *ohms*) than the other, it will get a proportionately higher share of the signal. A resistor that is more than ten times the value of the other resistor will get essentially all of the signal.

The converse is also true: a resistor that has less than one tenth of the value of the other will get less than ten per cent of the signal.

It follows that, if we had a resistor whose value we could change from one tenth of the value of a fixed resistor, up to ten times the value of that same resistor, we could control our audio signal all the way from almost nothing to full volume. This is how a volume control, or potentiometer, works. We can replace the knob in our volume control with a resistor that changes resistance with light, and we thus have a light-controlled volume control. Add two or more of these together, and we have a light controlled mixer.