Seismometer

by 10DotMatrix on October 8, 2014

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I tinker with things at Instructables.

Intro: Seismometer

Seismometers are instruments that measure motion in the ground, like the shaking produced by earthquakes. This seismometer is great for the amateur geologist because it is made from a few easy-to-find parts. Its design (based on a project found here) uses the electromagnet found in a typical audio speaker to mimic a geophone , a device that converts ground shaking to a voltage. The seismometer's output is read into the Intel Edison Board that connects wirelessly to the Internet of Things. The Internet of Things (or IoT) is a web of "smart" devices that uses wireless technology to talk to the web and us. This seismometer connects to Intel's IoT Dashboard in the cloud, where it automatically stores and updates the data it collects. Connect an array of seismometers to the cloud and easily build your own seismic network.

Components for the woofer geophone and base:

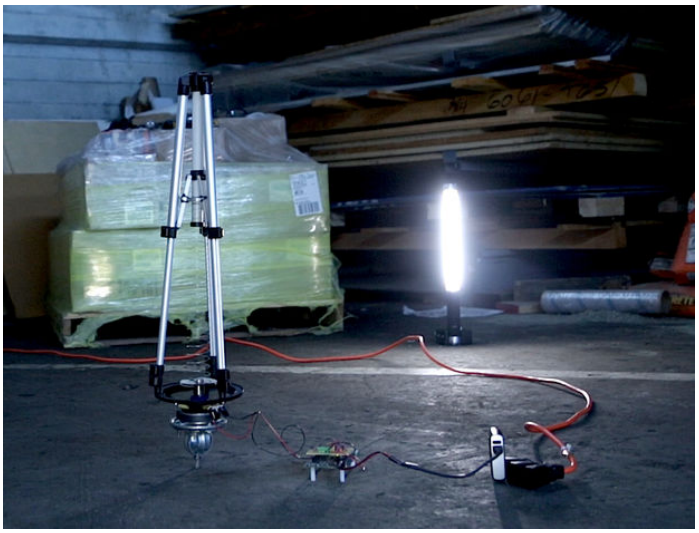
- (x1) 80-100W Woofer Newegg
- (x1) Camera Tripod Amazon
- (x2) Metal Original Slinky Jr. Amazon
- (x1) Metal Weight or Fishing Sinker (mine was ~55 g and purchased from TAP Plastics)
- (x6) Plastic cable zip ties Amazon
- (x1) Water bottle cap
- (x7) Small Screws (3 for the tripod and 4 for the base)
- (x1) Iron plate with a diameter similar to the woofer's magnetic bottom, with holes pre-drilled into it (I found mine at Cole Hardware)
- (x2) U-shaped pipe support bracket, normally used to attach water pipes to walls. (I found mine at Cole Hardware)
- Long screw or an expansion bolt
- threaded insert
- Assorted washers and nuts
- Cardboard or paper plates

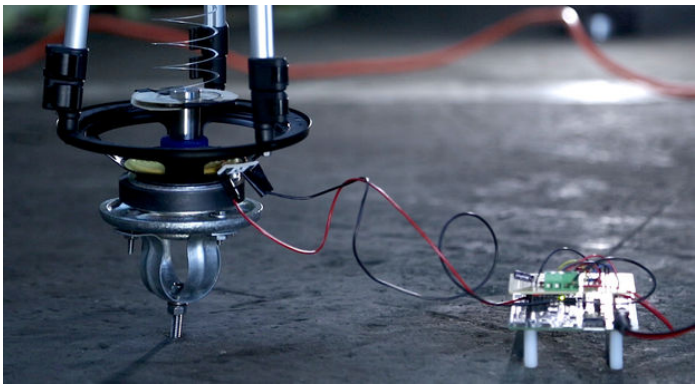
Useful tools for woofer geophone base:

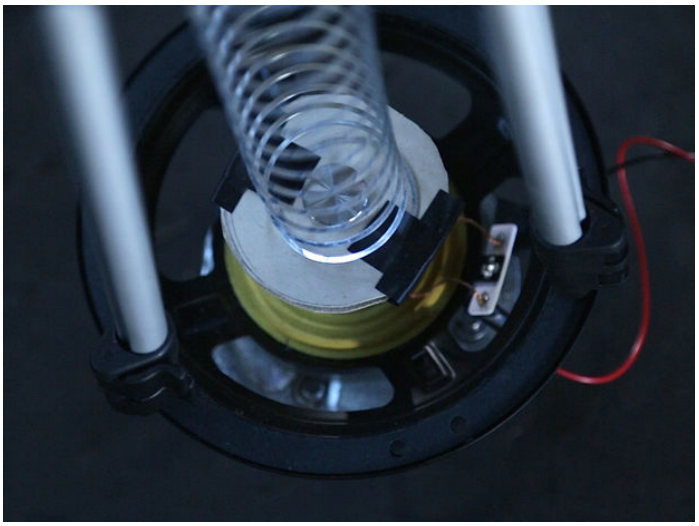
- Rotary hammer drill
- Masonry bit
- Punch
- Handsaw
- Epoxy
- Electrical or duct tape

Components for the Edison Board and circuit:

- (x1) Intel Edison and Breakout Board Sparkfun 13097
- (x1) PCB board Radioshack 276-147
- Male header pins Jameco 7000-1X10SG-R
- (x1) 2 or 4-pin Terminal Block Connector Jameco OSTYD040150
- (x1) AD620 Instrument Amplifier Mouser 584-AD620ANZ
- (x1) 333 ohm Resistor Jameco CF1/4W331JRC
- (x2) 10 Kohm Resistor Jameco CF1/4W103JRC
- (x1) 10 uF Capacitor Jameco R10/50
- Various wires



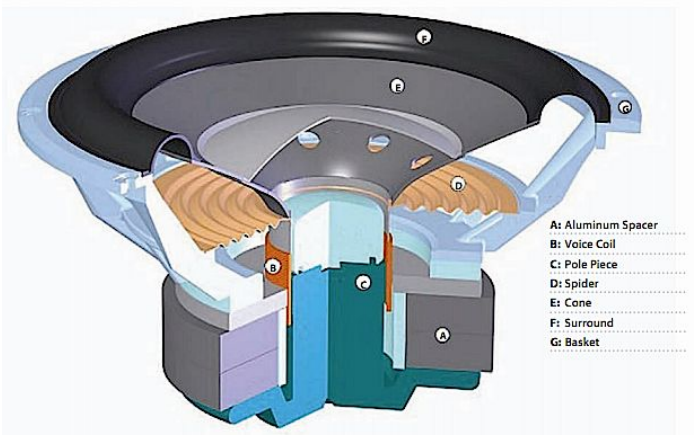




Step 1: Modify the woofer

First you'll need to find a woofer. I bought a Boss 80W 4 ohm woofer for this project. You can also take apart an old loudspeaker, but be careful not to damage the coil while extracting the woofer. 100W 8 ohm speakers are a safe and cheap option. Stronger woofers give stronger signals, but are more expensive.

Carefully cut away the woofer surround and cone using a pair of scissors and an X-Acto knife. The dust cap will be cut away too, but keep it attached for now. It will protect the voice coil from damage in the next few steps.



Step 2: Modify the tripod

Use a hand saw to remove the tripod's quick release camera mount. The tripod is made of thin, hallow aluminum, so removing it is relatively painless.

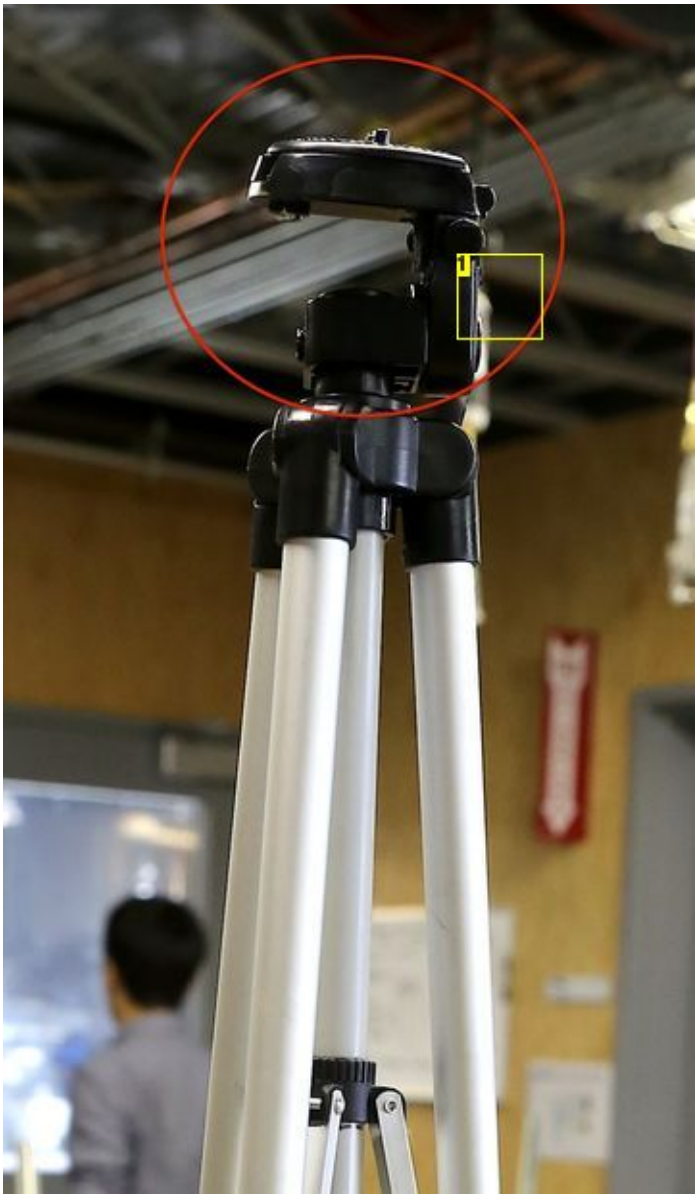


Image Notes
1. Before

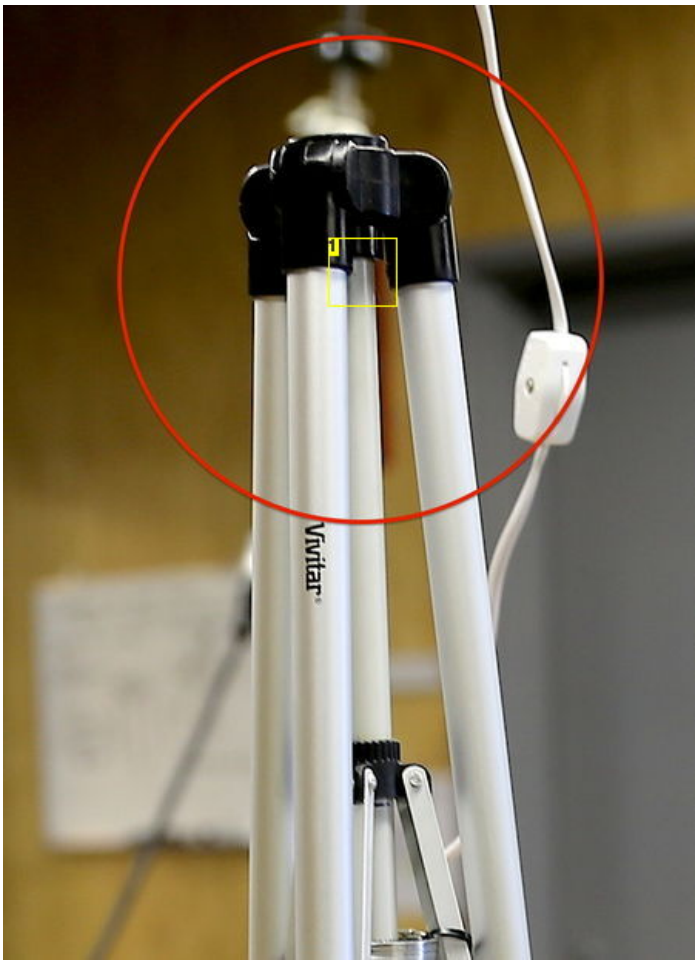


Image Notes
1. After

Step 3: Attach the woofer to the tripod

Flip over the tripod and position the woofer flat on top of its legs. My woofer came with holes pre-drilled into its frame. I attached the woofer to the tripod by drilling through these holes into the tripod's rubber feet.

Step 4: Replace the dust cap

Why replace the dust cap? Most woofers come with curved dust caps. We need a cover to protect the woofer's electromagnet, but need it to be flat so we can eventually glue a spring and weight to it.

Cut away the woofer's dust cap with an X-Acto knife. Mix two-part epoxy and apply a generous amount to the rim of a water bottle cap. Press the cap onto the woofer's spider over the voice coil. Apply pressure to the cap for half an hour while it dries.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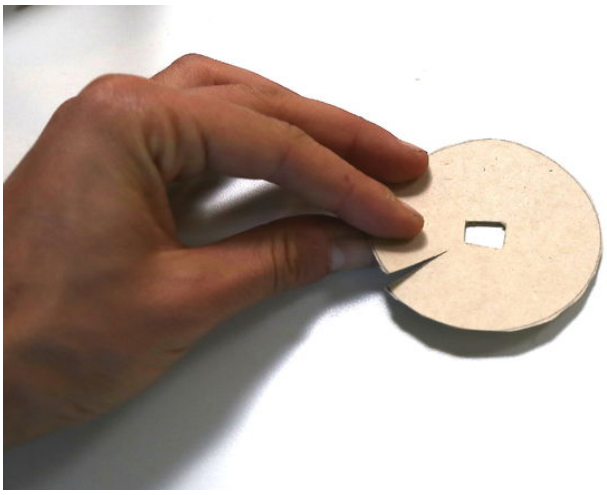
Part B

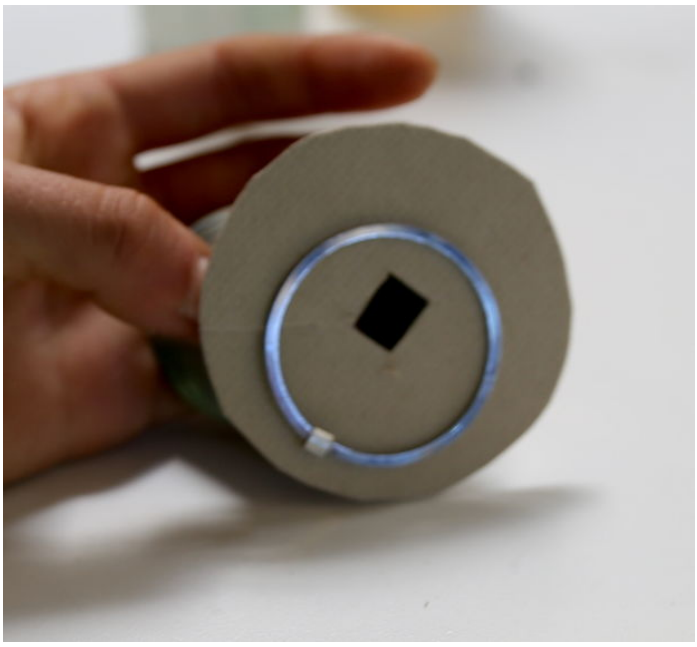
Step 5: Attach the weight to the spring

Use a junior slinky as the seismometer's spring. Choose a weight that won't warp the spring when it is fully stretched. I initially had problems attaching the weight while also keeping the slinky straight, so I developed the following trick.

Draw two circles onto a piece of cardboard (I used a paper plate) with a diameter slightly larger than the diameter of the slinky. Cut them out, cut holes in their centers, and cut slits in their sides. Take one circle and thread the end of the slinky through its slit. The circle should be caught in two turns of the slinky. Unscrew the top and bottom parts of the weight and push the weight's top (the side with the screw) into one side of the circle. Take the second cardboard circle and push it through the screw. Now two turns of the slinky are sandwiched between two cardboard circles. Screw on the bottom part of the weight. Tape both cardboard circles together to secure the weight.

Now the weight will exert equal force around the circumference of the slinky, keeping the slinky straight while it's stretched.



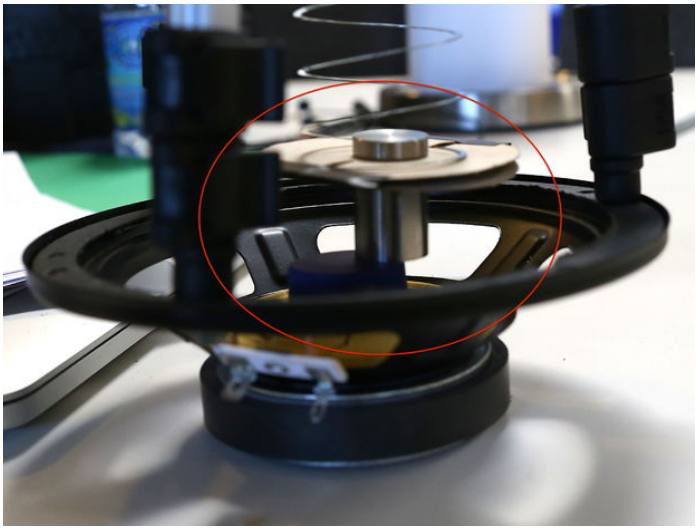


Step 6: Attach the spring to the tripod

The free end of the slinky will be attached to the top of the tripod's inner legs. However, the slinky must be positioned such that, when fully extended, its weight hovers just above the plastic water bottle cap.

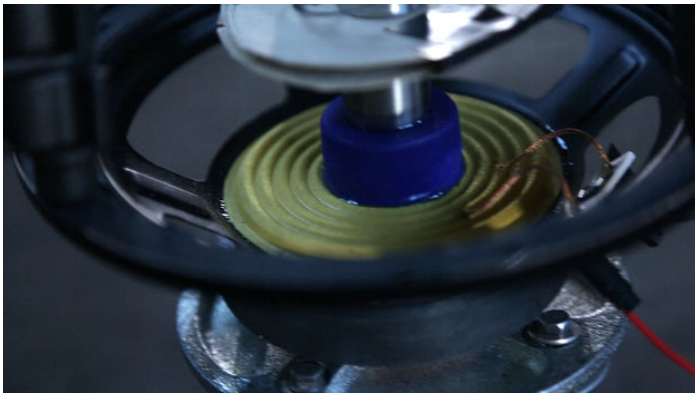
Hold the slinky inside the tripod and over the woofer at the height you want it hung. Keep one hand at the top of the slinky, and the other underneath the weight. Let the weight slowly extend the slinky while keeping the weight cupped in your hand. In its final position when the spring is fully extended, the weight should just about touch the plastic cap without exerting pressure on it or the spider of the woofer. If the slinky is too long, bunch more coils up at the top in your hand. If it's too short, release some coils to extend its length.

When the perfect length is found, there may be a lot of excess slinky. Use a pair of cutters to snip off the excess coils. Save a few excess coils so you can secure the slinky to the tripod with zip ties. Crisscross two zip ties around the excess coils and tripod legs and tighten.



Step 7: Glue the weight to the dust cap

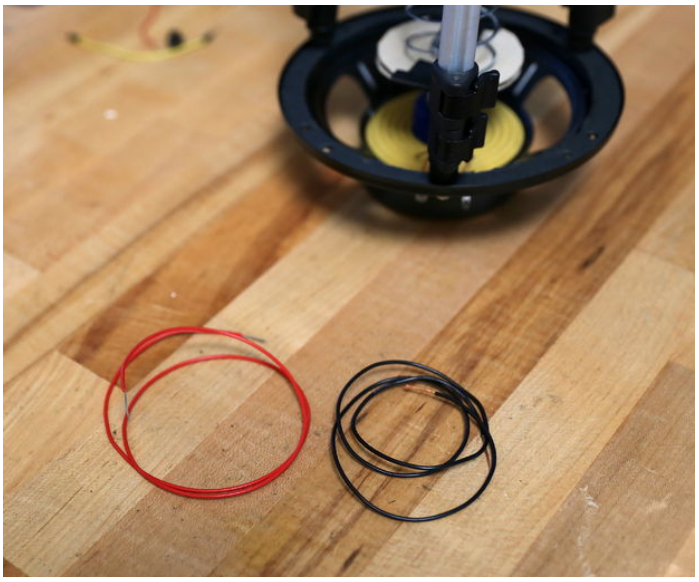
Apply superglue to the base of the weight and press it onto the plastic cap. Let it dry for 1/2 hour.

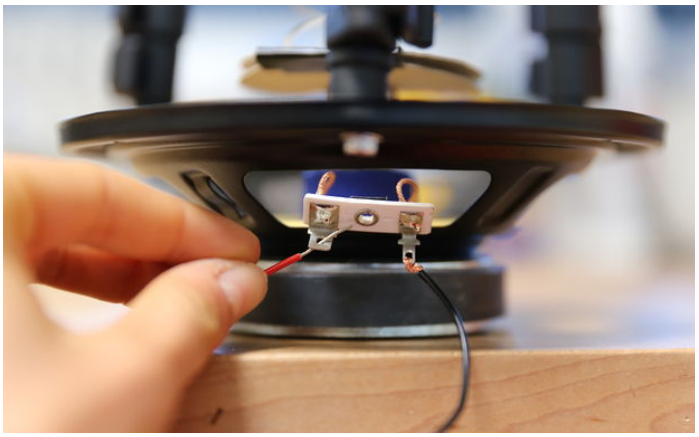


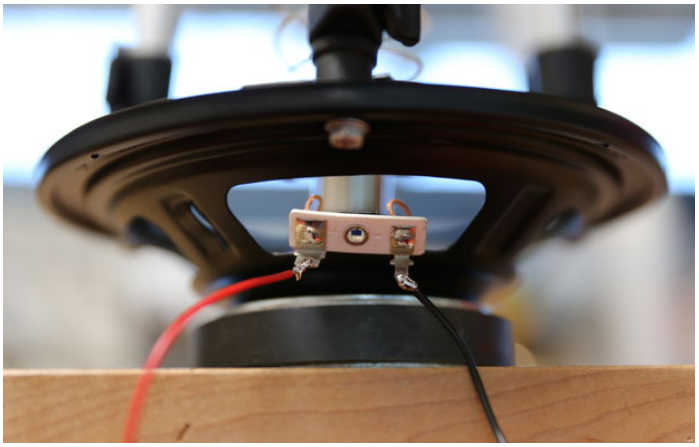
Step 8: Solder connectors

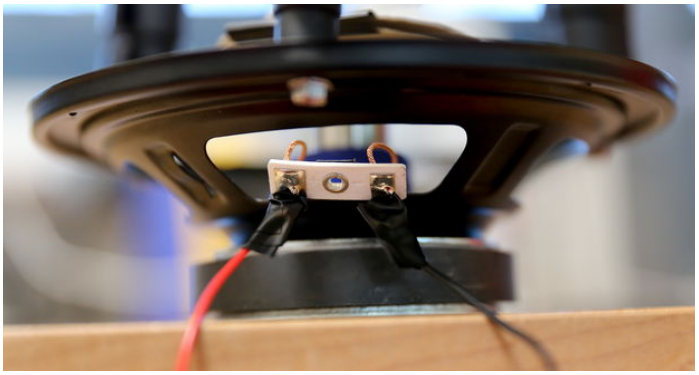
Cut and strip two pieces of braided wire. Solder them to the woofer outputs and wrap the connections in electrical tape.

Now the slinky and weight are attached to the spider, so that when the ground shakes, the spring shakes the weight over the woofer's magnet. This produces a current through the wires you just attached, although a very small one. This seismometer generators a signal on the order of a few milliamps, too small for the Edison to accurately detect. You will amplify this signal in the next step.









Step 9: Make the amplifier

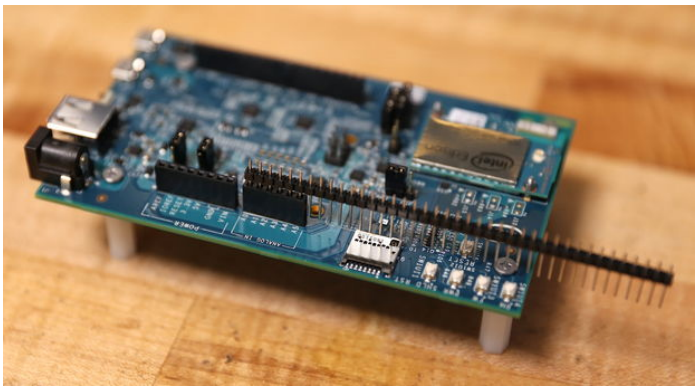
First make the shield for the amplifying circuit. Push header pins into digital pins 0 to 7, analog pins, and power pins on the Edison Arduino expansion board. Fit the protoboard into the pins and solder the pins to the board. This can be a bit tricky.

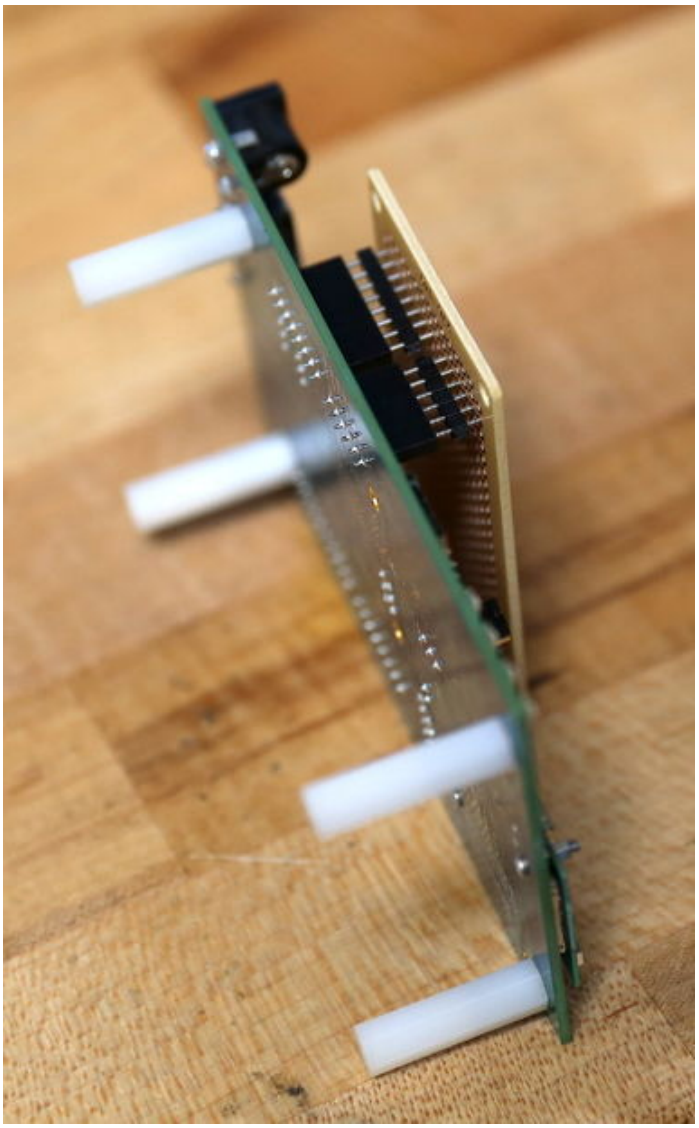
Follow the schematics included here to build an amplifying circuit. The circuit relies on the AD620 instrumental amplifier. This chip is very easy to use. Its gain can be tuned by adding a single resistor between pins 1 and 8, where its resistance is determined by the equation

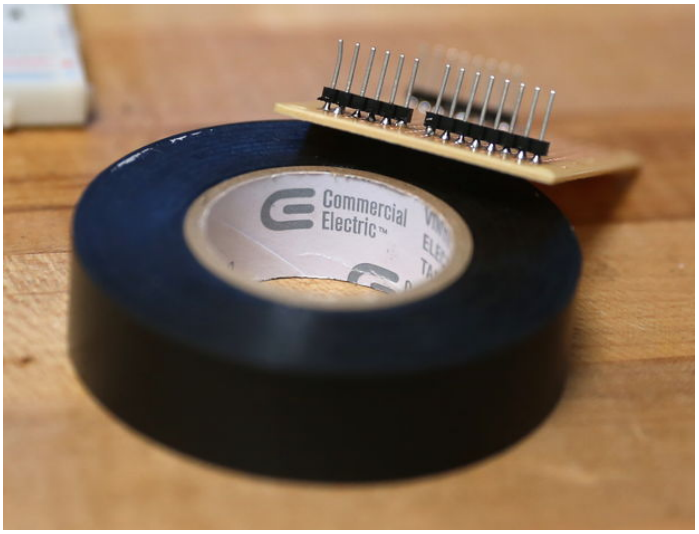
Gain = (49.4 kOhms/R) +1

which is found in the AD620 datasheet. The circuit is tuned to have a gain of 150, amplifying the seismometer's output to the order of 10^-1 amps.

The AD60's input comes from the seismometer's audio output. Instead of soldering the output wires directly to the Edison shield, I screwed them into two inputs of a four-input terminal block. This let me easily disconnect the seismometer from the shield if needed.



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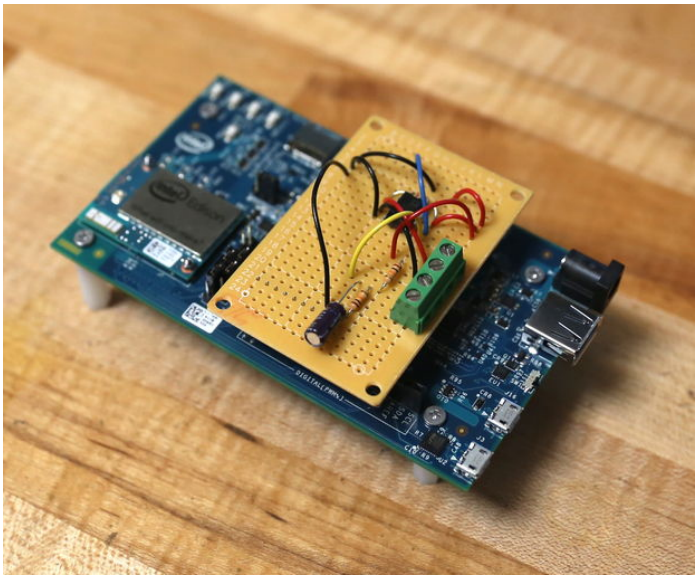
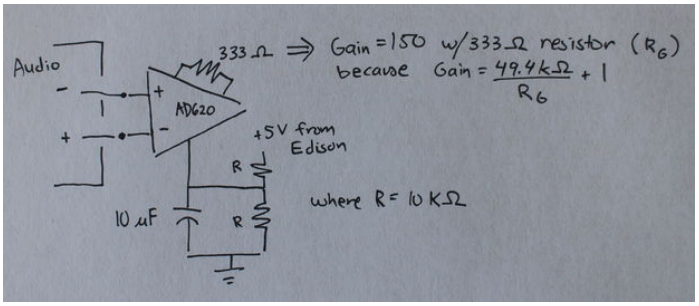
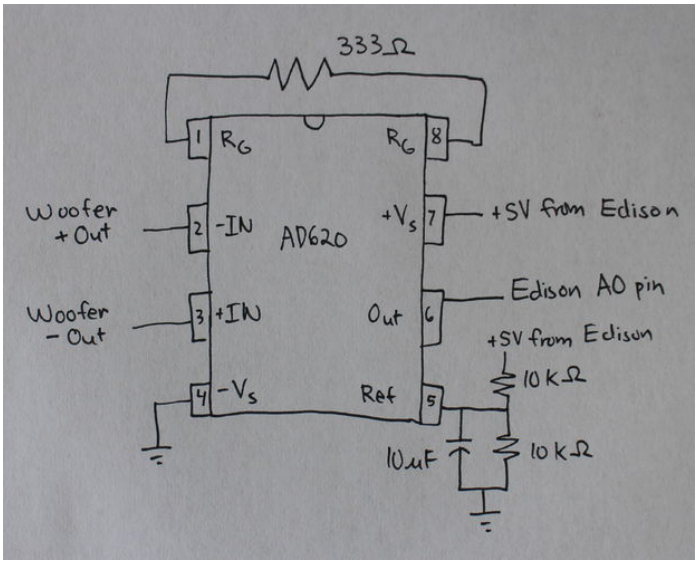






Step 10: Externally power the board

According to its documentation, the Edison can be powered off a computer, the wall, or an external battery. A typical alkaline 9V battery has a lifetime of 550 mAh. The Edison board will not draw more than 200 mA, but that leaves only about 2.75 hours of battery lifetime! Hopefully you won't be feeling an earthquake in the next 3 hours! This seismometer needs to run for a long long time, so make sure to plug it into an outlet.

Power the Edison through its M-barrel connector with a 5V 2-3A AC power adapter. This provides a regulated 5V to the board and enough current for its wifi card. You can also power the Edison with a micro usb cable, but this won't provide enough current for wifi use.

File Downloads

Intel Edison Kit for Arduino.pdf (1 MB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'Intel Edison Kit for Arduino.pdf']

Step 11: Edison code

Download the code provided here and follow my Intel IoT Analytics Dashboard guide to learn how to properly setup and use your Edison to connect to the cloud.

The Arduino code for this seismometer is based on Intel's example program that comes with the Arduino library. It collects analog data from the seismometer and shares it with the cloud every half hour.

File Downloads

seismometer.ino (1 KB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'seismometer.ino']

Step 12: Make the base

Make a base for fixing the seismometer to the ground. Using an iron base has the advantage that it magnetically attaches to the woofer. Additionally, the base needs to attach the geophone firmly to the ground, which I did by screwing it into a hole in the floor.

To make the base, drill holes into the center of two pipe brackets. Make sure the holes are aligned when the brackets are mounted to the base plate.

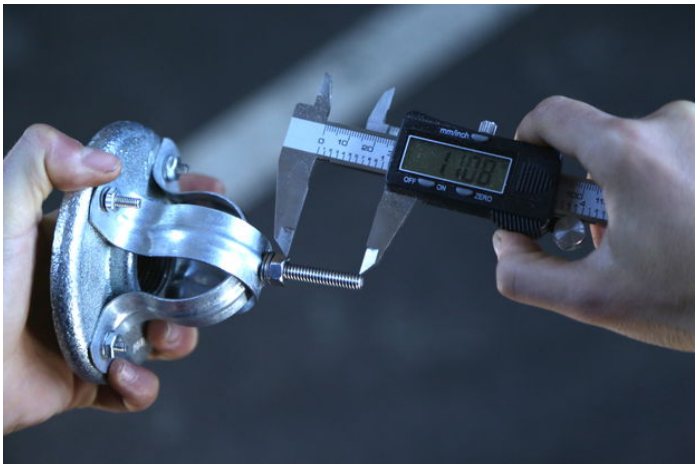
Mount the first bracket to the base plate with two screws and washers. Mount the second bracket at a right angle relative to the first. I had to bend the second bracket inward a bit so it could fit over the bottom bracket and onto the plate.

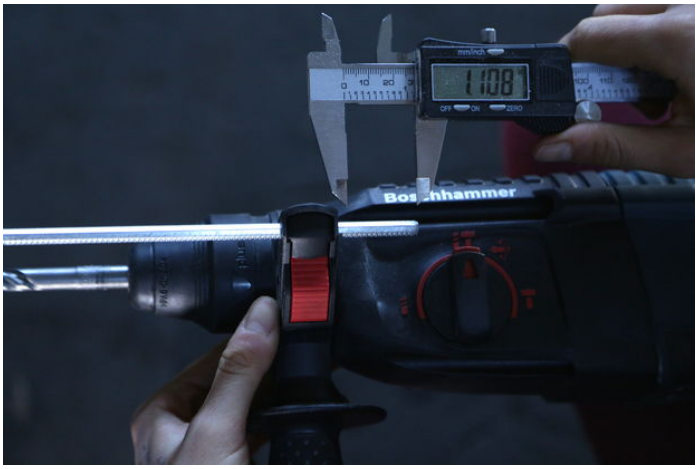
Finally, screw a nut onto a long screw about two inches from its gimlet point. Flip the plate over and thread the screw through both pipe brackets. Secure it down with another nut.

Step 13: Prepare to drill a hole

Determine where you'll install your seismometer. The ideal location is: covered with concrete or asphalt, sheltered from wind and rain, quiet, and free from vibrations. If you are unable to drill into the ground, use a solid block of concrete instead.

Once the location is set, measure the length of the screw protruding from the metal base plate. Adjust the guide on your hammer drill (a device that looks like a cross between a jack hammer and a ray gun) so it matches the length just measured. This will keep you from drilling too deep. Make sure to also replace your drill bit with a masonry bit, which is meant for drilling into asphalt.



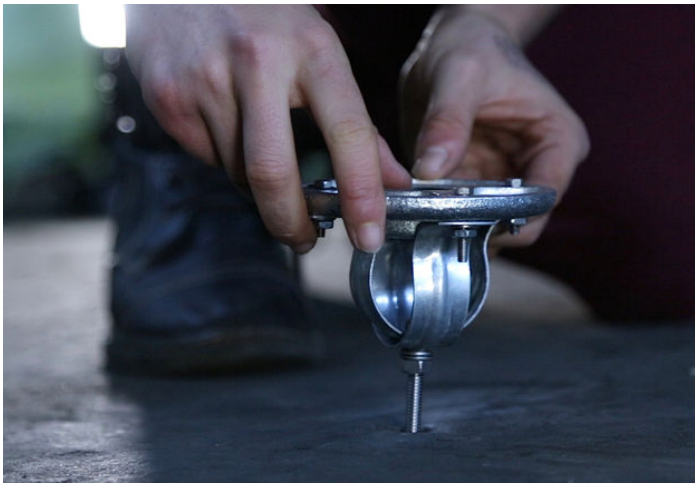


Step 14: Drill a hole

Apply steady pressure to the hammer drill while boring through concrete or asphalt. Make sure to keep the drill normal to your surface, and keep the drill running while retracting it from the asphalt. When finished, brush away any dust to keep it from collecting in the hole.

Step 15: Screw in the base

Slip a treaded insert into hole, and hammer it down using a punch. Screw the base into the threaded insert and tighten with a screw driver.

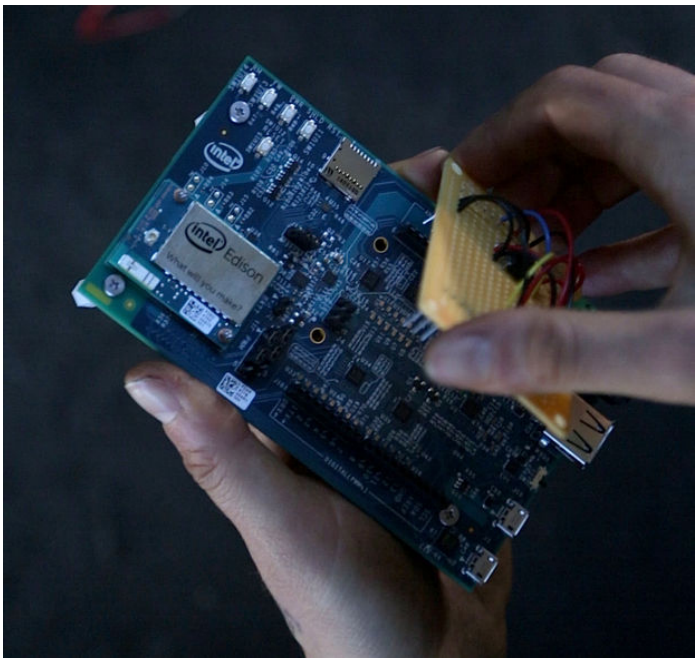


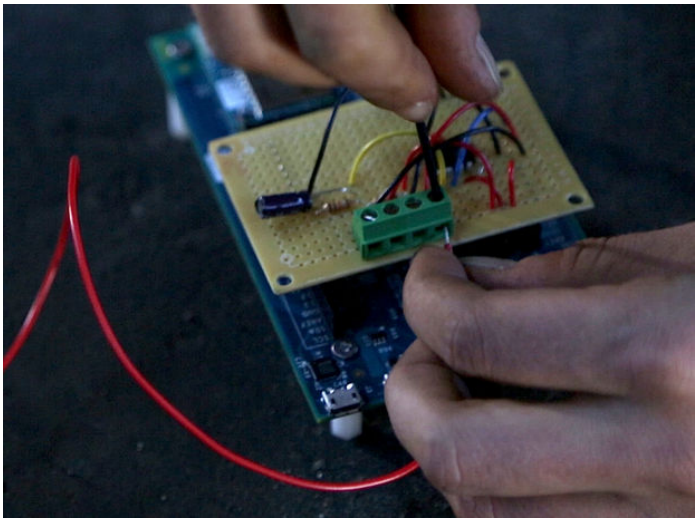
Step 16: Putting it all together

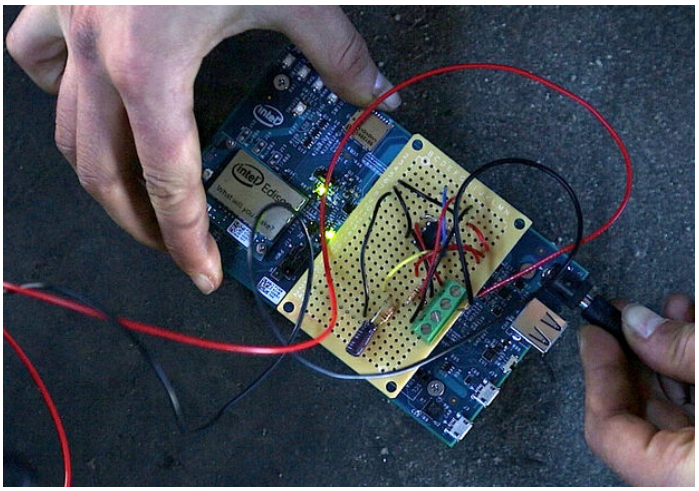
Magnetically snap the seismometer onto the top of the base.

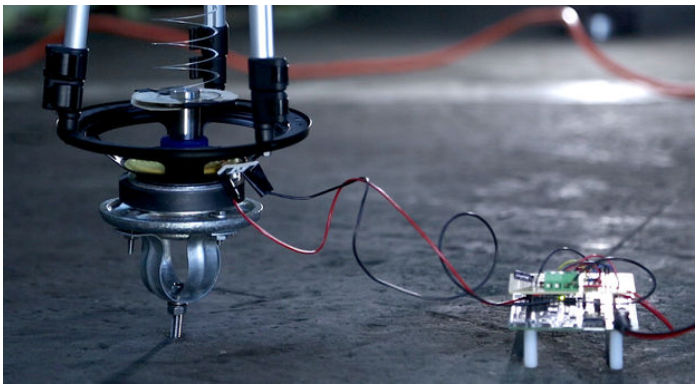
Push your circuit board into the Arduino Edison expansion board. Screw the seismometer's output wires into the board's terminal blocks with a small screw driver.

Finally, connect the Edison to power as described in the previous steps.



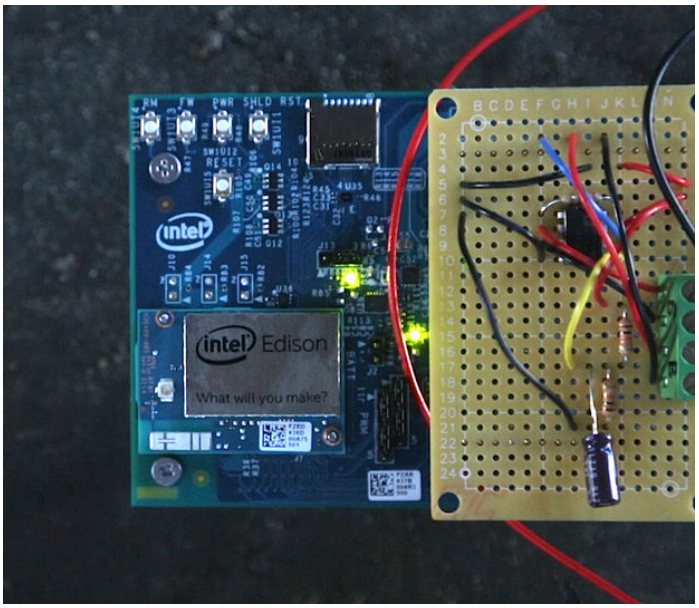






Step 17: Help the scientific community

Start recording ground motion with your new seismometer!



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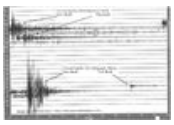

This Seismometer is no toy! by barkergk

Comments

1 comments **Add Comment**

ogrossman says: Nov 24, 2014. 1:01 PM **REPLY**

Any thoughts about calibration?