Motion-Activated Solder Fume Extractor With Lamp

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Overview

This is a solder fume extractor with a couple of twists. Besides an internal rechargeable Lithium Polymer (Li-Poly) battery for portability, this extractor incorporates a low-power motion detector and a USB A accessory connector. When you reach for your soldering iron, the motion detector turns on the extractor’s fan for a predefined period then turns it off to preserve battery power. An LED reading lamp can be connected to the accessory port to eliminate shadows in the work area. This one is also ambidextrous; flip it end-for-end to point the motion detector at the soldering iron holder to the right or to the left of your work area.

The fume extractor was built into an off-the-shelf ABS plastic enclosure; no 3D printed parts were used. The enclosure comes from the manufacturer without any holes so we'll be drilling some with diameters ranging from 1/8 to 1-7/8 inches. Beginning makers may have some trouble with the larger holes, so don't hesitate to ask for help from someone with fabrication experience. We'll include a printable, actual size layout and drilling guide to assist when preparing the enclosure.

As with any project involving power tools, sharp implements, and hot soldering equipment, safety is your primary concern. Review tool operational safety instructions before beginning this project. Be careful!

Inspiration for this project came from makers like Phillip Burgess and many others with unique solder fume extractor designs. Thank you for the ideas!
Project Components

Adafruit Components:

- **PowerBoost 500 Charger** ([http://adafruit.com/product/1944](http://adafruit.com/product/1944)) -- a boost converter that is the hub of this project. It manages the battery and provides 5 volts to the fan, motion detector, and lamp connector. Do not install the USB-A jack that comes with the PowerBoost board; set it aside for another project.
- **PIR (Motion) Sensor** ([http://adafruit.com/product/189](http://adafruit.com/product/189)) -- the sensor that will detect movement near the soldering iron. This is a low-power sensor that conserves battery life.
- **Lithium Polymer (Li-Po) Battery - 3.7v 500mAh** ([http://adafruit.com/product/1578](http://adafruit.com/product/1578)) -- the rechargeable battery that provides portability. This battery is matched to the PowerBoost, so don't replace it with a battery of lower capacity. The Adafruit Li-Po battery has internal over/under charge protection that extends battery life and keeps things safe.
- **N-Channel Power MOSFET** ([http://adafruit.com/product/355](http://adafruit.com/product/355)) -- amplifies the output from the motion sensor to provide power to the fan.
- **Panel Mount Extension USB Cable - Micro B Male to Micro B Female** ([http://adafruit.com/product/3258](http://adafruit.com/product/3258)) -- provides an external connection to the PowerBoost to charge the battery. The male connector will be removed, the cable shortened, and data wires removed so that it will fit inside the enclosure.
- **Panel Mount USB Cable - A Male to A Female** ([http://adafruit.com/product/908](http://adafruit.com/product/908)) -- the 5 volt power output connector for the LED reading lamp. Like the micro USB connector, this will be modified to fit.

Other Components:

• 5Volt Brushless Fan, 10.5 CFM, 180mA ([#2150774 http://www.jameco.com](#2150774 http://www.jameco.com)) -- the air mover for this project. If you substitute something else for this highly efficient fan, you may have to recharge the battery more often.

• ABS Plastic Enclosure, Hammond 1594-DBK ([#HM229-ND https://www.digikey.com](#HM229-ND https://www.digikey.com)) -- a blank box that will be modified as needed.

• Activated Carbon Filter Material ([#WSA350F-ND https://www.digikey.com](#WSA350F-ND https://www.digikey.com)) -- treated filter foam, 1/4" thick. We'll cut this to size.

• Acrylic Rod 6 inch long, 1/8 inch diameter ([#23639 https://www.tapplastics.com](#23639 https://www.tapplastics.com)) -- used to hold the filter material in place. Any 1/8 inch diameter rod or wooden dowel will work. We will cut this into two 2-5/8 inch lengths.

• Clear Ribbed or Prismatic Plastic Sheet, 1-3/4 x 2-1/4 inch, 1/8 inch thickness ([Sample #99998 https://www.tapplastics.com](Sample #99998 https://www.tapplastics.com)) -- mounted behind the front panel's windows to allow the PowerBoost's LED lights to be seen from outside the enclosure. You can use almost anything that's transparent or translucent, so feel free to be creative.

• USB-Powered Gooseneck LED Reading Lamp ([Modern Lamp https://www.amazon.com](Modern Lamp https://www.amazon.com)) -- optional lamp that plugs into the fume extractor's USB-A connector. The listed lamp has adequate brightness, is dimmable, and doesn't draw the battery down very quickly.

Fasteners, Supplies, and Tools
Fasteners

- 6 each M2.5 x 4mm nylon screw
- 6 each M2.5 x 6mm nylon screw
- 1 each M2.5 x 10mm nylon screw
- 1 each M2.5 nylon hex nut
- 6 each M2.5 x 6mm nylon threaded standoff
- 4 each M2.5 x 16mm steel screw
- 4 each M2.5 x 6mm steel flat washer
- 4 each M2.5 steel hex nut

The nylon fasteners are included in the Adafruit M2.5 Black Nylon Screw Set (https://www.adafruit.com/product/3299).

Steel screw fasteners were obtained from Tacoma Screws (www.tacomascrew.com).

Supplies

- 3 each heat shrink tubing, 3/4 inch long, 3/32 inch diameter (https://www.adafruit.com/product/1649)
- Washable glue stick
- Gel-type superglue, E6000 adhesive, or acrylic cement.
- Solder
- Two tiny dots of blue tack (Fun-Tak Mounting Putty https://www.amazon.com)

Tools

- Small Phillips screwdriver
- Wire strippers (https://www.adafruit.com/product/527)
- Wire cutters (https://www.adafruit.com/product/152)
- Scissors
- Sharp hobby knife
- Soldering iron
- Hand countersink tool
- Automatic or manual center punch
- Power drill or drill press with:
  - 1/16 inch drill bit
  - 1/8 inch drill bit
  - 1-7/8 inch hole saw (https://www.grainger.com)
Make the Enclosure

In this section, we'll describe how to lay out and drill a stock electronics enclosure using paper drilling guides. Paper, glue, tape, drill bits, a hole saw, and a power tool. What could be better than that?

Prepare the Drilling Guides

To make it easier to drill holes in the enclosure, we'll use a two paper drilling guides. These are printed from two actual-size .pdf files, cut out with scissors, taped where corners are needed, and temporarily glued to the enclosure to locate drill bits accurately when making holes. One drilling guide is used for the front panel. The
other covers the rear panel and the adjacent four sides. They look like those in the photo when they’re ready to be glued to the enclosure.

Download Sides/Rear Panel Drilling Guide (.pdf)

Download Front Panel Drilling Guide (.pdf)

Download, open, and print the two drilling templates.
Print actual size using the automatic portrait/landscape or the landscape orientation option.

Carefully cut out each guide template using a sharp pair of scissors.
Fold the sides/rear panel guide to create a box shape that will slip over the rear panel of the enclosure.
The front panel guide will not need to be folded.

To get a straight and sharp fold, use a ruler as a guide. Place the ruler along a fold line and lift the side to be folded.
With the ruler still in place, crease with your fingernail to define the fold.
Draw the edge of the ruler along the creased fold. This will further establish the crease and will make it sharp and straight. Repeat this folding technique for all four sides and the side attachment ears. Fold the sides up to form a box shape. Tape the insides and outsides of the corners.

In the next section, the two guides will be glued to the enclosure. After that we'll do some drilling.

### Attach the Guides to the Enclosure

The sides/rear and front panel drilling guides will be attached to the plastic enclosure using a washable glue stick. Many office supply glue sticks are water-soluble, but one that's clearly labeled as washable is recommended. The one shown is a quick-dry formulation. If you're a beginning enclosure fabricator, then you may prefer to use the slower drying variant to give you more time to position the drilling guides. It's very nostalgic to get to use school paste in a project!
Attach the front cover with the screws supplied with the enclosure. Don't over tighten the screws. Snug is good enough for now. The enclosure is stronger with the front cover in place, making it more stable and easier to drill.

Apply a thin coat of glue to the four sides and the rear panel (the one without the mounting screws).

With the rear panel facing upwards, slide the sides/rear panel guide into place. Carefully align it and square it up with the enclosure, then press it into place with your fingers.
Using the edge of a ruler, gently burnish each guide surface to secure the guide to the enclosure. Don't be too enthusiastic in this step. We don't want to scrape off the printing!

Flip the enclosure and apply glue to the front panel (the one with the screws).

The large yellow filter hole of the front panel guide should be directly above the large fan hole of the rear panel guide. Align the front panel guide with the edges of the front panel and press into place.
Burnish the front panel guide to assure that it bonds tightly with the enclosure.

Tape down the edges of both guides to completely secure them to the enclosure. Blue painters' tape works well for this step. When taping, don't cover any holes that need to be drilled-- makes 'em tough to find!

After taping the guides, the overall enclosure should look like this (rear panel view). The tape is holding down all the guide edges but is not covering the acrylic rod holes on each of the two larger sides.

Allow at least 15 minutes for the glue to set before moving on to the next step.
Use a small, sharp center punch to create an indentation in the exact center of each hole. The indentation will help to guide the pilot drill in the next step. The holes to be drilled are yellow circles with a small black dot in the center. A manual or automatic center punch can be used in this step. The photo shows the use of an automatic center punch adjusted to a low impact setting, perfect for soft plastics.

We're ready to drill some holes now, so off to the workshop we go!

Drill the Holes and Remove the Guides

Let's head out to the workshop bench to do some drilling then to the kitchen sink to remove the paper drilling guides. Do you remember that the glue underneath the guides was washable?

The drilling is fairly simple since the enclosure is a soft ABS plastic. Drill bits have a tendency to drift away from center of the hole in soft materials like ABS unless you use a drill press. Since we'll be using a hand-held power drill for this build, we'll solve the drifting issue by drilling two successive sizes of pilot holes.

Small pilot holes are the best way to accurately guide larger drill bits. Be patient -- the components will fit better if the holes are drilled with precision. Take it slow and easy.
Carefully center the drill bit before spinning the drill. Use light pressure at a slow speed and let the drill bit do the work.

Start by drilling 1/16 inch pilot holes in the center of each hole marked on the drilling guide. The holes to be drilled are yellow circles with a small black dot in the center. After drilling all the hole centers with the 1/16 inch drill bit, repeat the process and enlarge all the holes with the 1/8 inch drill bit.

Because the final diameter of many of the 27 holes is 1/8 inch, only eight larger holes remain to be drilled at this point. Let's start with the two largest holes, 1-7/8 inch. These are for the carbon filter in front panel and the fan in the rear panel.

Clamp the enclosure to your work surface to stabilize it when using the larger drill bits and hole saw. Two clamps placed as shown should do the job.

A sharp hole saw will do most of the work for you. Your primary job is to apply a light, even pressure and to keep the hole saw level while drilling.

Hole saws can create a lot of torque that can cause the power drill to suddenly stall and jerk, damaging the enclosure. In addition to spinning the drill at a lower speed and letting the hole saw do the work, set the power drill clutch to a medium setting. If the hole saw grabs or stutters, the clutch will keep the power drill from suddenly twisting in your hands.

Using the 1-7/8 inch hole saw, start drilling by placing the hole saw's pilot bit point into the previously drilled pilot hole. Run the drill motor at a low speed. After the saw completes the hole, pry out the plastic circle that's inside the hole saw, flip the enclosure, secure the clamps, and drill the second 1-7/8 inch hole.
The final eight holes will require a special drill bit that can cut a variety of hole sizes. The step drill bit shown below can create hole sizes from 3/16 to 7/8 inch, perfect for our remaining 1/4, 3/8, 9/16, and 7/8 inch holes.

A step drill bit works very well with plastics, smoothly cutting a precisely round hole. The trick is knowing when to stop drilling -- when the step drill bit has reached the correct diameter. You will be able to feel it as the drill moves from one diameter to the next. If you haven't used a step drill bit before, try it out on some scrap material and get the hang of it before drilling the enclosure.

Operate the step drill bit at a slow speed using light pressure. Hold the power drill level while drilling. The step drill bit should create some nice spirals of cut plastic if you're doing it correctly.

Using the step drill bit, drill each of the remaining eight holes to the size printed on the drilling guide.

Use a hand countersink tool to remove any burrs from the smaller holes. A small file can be used on the larger holes to smooth away any roughness left after drilling.

At this point in the process, you will only be able to remove burrs from the enclosure's exterior. Keep the countersink and small file handy for later. You'll have the opportunity to clean up the interior after the guides and front panel are removed.
After creating a nice mess in the workshop, it's time to head to the kitchen sink and remove the drilling guides.

Peel off all the blue tape and as much of the paper as possible. Rub off the remaining paper and glue under lukewarm running water. The washable glue will completely dissolve. Dry with a paper towel.

Remove the front panel screws and eliminate any interior burrs with the countersink and a small file.
Here's a glamour shot of the enclosure after drilling. We'll need room to fiddle with the wiring, so the acrylic rods and the prismatic plastic window will be attached later.

Now on to the electronics part of the project!

### Wire, Solder, and Test

![Image of electronics components](image)

Time to warm up the soldering iron. Too bad we don't have a solder fume extractor to use just yet.

In this section, we will cut and prepare the wires then solder them to the components. After soldering, we'll plug in the battery to confirm that everything works as planned.

The components will be mounted into the enclosure after wiring and testing is complete.

### Wire and Solder

The two USB cable assemblies will be cut to length then modified to remove the shielding (a braided wire covering with a bare drain wire) and the white and green data wires. Since the extractor only uses USB power and doesn't process data, we will only need the red and black wires.

The next step is a bit tricky, but if you take it slowly and carefully, you'll find that this technique is an excellent way to remove the thick outer insulator of a multiconductor cable without damaging the internal conductors.
• Cut the two USB cables to the indicated lengths. We won't need the male conductors for the extractor, but you may want to keep them in your parts bin for a future project.

• To remove the outer black vinyl sleeve, bend the cable back sharply within 1/4 inch of the panel mount connector.
• Holding the cable and connector in one hand, slowly and lightly draw the blade of a sharp hobby knife back and forth across the vinyl sleeve until you feel it contact the first layer of the cable, the braided shield -- then stop cutting. You should see the braid peeking through the slot you just made.
• Work your way around the entire circumference of the cable, bending the cable as needed to cut through the vinyl sleeve to expose the braided shield.

• To remove the vinyl sleeve, lay the cable flat on a tabletop. Draw the knife blade along the length of the vinyl sleeve in a straight line, splitting the sleeve but not
cutting deep enough to score the braid. Start at the point where the braid was exposed and scribe the sleeve to the cut end.

- You should be able to grasp the scribed sleeve with your fingers and pull it away from the cable. The sleeve should easily give way along the scribed cut line.

![Image of a cable with a scribed sleeve being pulled away](image)

- Remove the braided shield by pushing it towards the panel connector. The braid should bunch up as shown.
- Use sharp wire cutters or scissors to cut the small braid wires close to the panel connector.
- Once all the small wires are cut, slide the braid off the cut end of the USB cable.

![Image of a USB connector with cut wires](image)

- Untwist the bare shield drain wire and the secondary shield foil. Use the wire cutters to cut them close to the panel connector.
- Cut the white and green data wires as shown. To keep the ends of the data wires from touching any other wire or remnants of the shield, cut the white wire 1/8 inch from where the shield was removed. The green wire should be cut 1/8 inch longer than that so that its end won't touch the end of the white wire.
- Repeat the process for the other USB cable.

You now have two USB panel connectors with just the red and black power wires that will be connected to the PowerBoost board later.
Cut the remaining component wires as follows. Save the wire cuttings to re-use for the power switch and for the N-Channel MOSFET.

**Fan:**

- Cut the black wire to 3 inches in length; save the remnant for the N-Channel MOSFET
- Cut the red wire to 5-1/4 inches

**PIR (Motion) Sensor cable:**

- Cut the yellow wire to 4-1/4 inches; save the remnant for the On/Off Switch
- Cut the black wire to 4 inches; save the remnant for the On/Off Switch
- Cut the red wire to 4 inches

**On/Off Switch:**

- Cut the yellow and black wires (remnants from the sensor) to 4 inches

**N-Channel MOSFET:**

- Cut the black wire (remnant from the fan) to 4-1/2 inches
Using wire strippers, remove 1/8 inch of insulation from the cut end of all wires. Tin the exposed wire with a small amount of solder.

This is the wiring diagram for the extractor. We'll solder wires to the N-Channel MOSFET's pins and the power switch before connecting all the component wiring to the PowerBoost 500C board.

Note that the wire attached to the MOSFET's drain pin (D) is the fan's black wire, not gray as shown in the diagram. It was changed to gray in the diagram to make it easier to read.
For this step you’ll need the fan, the N-Channel MOSFET, the three-wire connector for the PIR (motion) sensor, the 4-1/2 inch black wire, and three short lengths of heat shrink tubing. When this step is completed, it will look like the photo on the right.

- Prepare the MOSFET's pins by bending them as shown with a pair of needle nose pliers.
- Slip a heat shrink sleeve over the sensor connector's yellow wire and slide it out of the way.
- Bend the tinned end of the yellow wire into a U-shape.
- Interlock the wire with the MOSFET gate pin (G), then solder the two together.
- Repeat the soldering process for the black fan wire that connects to the MOSFET drain pin (D) and for the 4-1/2 black wire that connects to the MOSFET source pin (S).
- Cover the connections with the heat shrink tubing. Shrink the tubing with the shank of the soldering iron tip.

- Bend a tinned end of the 4-inch black wire and the 4-inch yellow wire into a U-shape.
- Slip the black wire into the hole of the center terminal of the On/Off Switch. The yellow wire attaches to one of the remaining two terminals.
- Solder these two connections.
Solder the component wires to the PowerBoost 500C board as shown in the wiring diagram.

Push the wires through the holes from the bottom and solder from the top. After soldering, use the diagonal wire cutters to remove the excess wire length that may be sticking through the top of the board.

Move the retrigger jumper on the PIR (motion) Sensor to the top two pins -- the H position.

For the test, set the Fan Duration and Motion Sensitivity adjustments fully counter-clockwise; minimum fan duration and motion sensitivity.

Noting the color-coding, plug the sensor cable connector into the three pins on the bottom of the sensor module. Black to the left (ground) with red to the right (+5 volts).

Everything should be connected now, except the battery. Double-check the wire connections per the wiring diagram. If it all checks out, you're now ready to move on to the testing phase where we'll plug in the battery and watch as the fan spins and lights glow.
Test the Circuitry

Time to test the extractor wiring with the battery and lamp attached. The circuitry will be installed in the enclosure after all tests have passed.

Plug the battery into the PowerBoost's battery connector, red wire on the left, black wire on the right.

Flip the on/off switch to the on position. The fan should start to spin and the PowerBoost's blue LED will glow. Wait for the fan to stop spinning then re-trigger it by passing your hand in front of the motion sensor. If the PowerBoost's blue LED is not lit or if the red LED is glowing, then the battery may need to be recharged before conducting the circuitry test.
Plug the reading lamp into the USB-A panel connector and turn on the lamp's built-in power switch. The lamp should light. Run the extractor circuitry through a motion detection cycle. The lamp should stay lighted even when the fan is not running.

• The final test of the extractor circuitry is to test battery charging. Plug a charging cable into the micro USB panel connector. The PowerBoost's yellow LED should glow, indicating that the battery is charging.
• Turn the reading lamp off, then flip the extractor's on/off switch to the off position. The yellow lamp should continue to glow while the battery charges.

Here's the decoder ring for the PowerBoost's LEDs: Blue when power is on; Yellow whenever the battery is charging; Green when the battery is fully charged; Red when the battery is low.

Assemble the Extractor
Now that we know the circuitry works, let’s put everything in its place. We'll use some steel and nylon fasteners as well as a few spots of glue.

Unplug the battery to begin the assembly process. It's safer that way.

Prepare the PIR sensor and the PowerBoost by attaching six M2.5x6mm threaded nylon standoffs to the printed-circuit board mounting holes with M2.5x4mm nylon screws. The longer M2.5x6mm nylon screws will be used to attach the standoffs to the enclosure in a later step.

Mount the components to the interior of the enclosure in the order shown.

1. Fan
   - Orient the fan with the wires exiting towards the top of the enclosure.
   - Use four M2.5x16mm steel screws, flat washers, and hex nuts.
   - Place the washers and nuts on the interior side of the fan.

2. N-Channel MOSFET
   - Position the MOSFET so the pins and connected wires are to the right.
   - Attach with one M2.5x10mm nylon screw and hex nut.
3. micro USB Panel Connector

- Attach using the included steel screws.

4. PowerBoost 500C

- Position the board with the battery connector towards the enclosure bottom side.
- Secure with four M2.5x6mm nylon screws.

5. Li-Po Battery

- Mount on the bottom side of the enclosure using two very small dots of blue tack putty.
- Wait to plug the battery wire into the PowerBoost until all components are installed.

6. PIR (Motion) Sensor

- Orient the sensor with the two adjustment controls facing outwards.
- Attach to the right side of the enclosure using two M2.5x6mm screws.

7. On/Off Switch

The switch mounts using its threaded shaft.
Remove the outer nut and lockwasher.
By hand, spin the lower nut onto the shaft as far as it can go. This will provide a longer shaft outside the enclosure.
Insert the switch shaft into the hole in the enclosure's back panel.
8. USB-A Panel Connector

- Attach with the included steel screws.

At this point, all the primary components are attached. Re-connect the battery to the PowerBoost and test to see that the extractor is working properly.

Set the PIR sensor's duration and sensitivity adjustments as shown. This level of sensitivity will detect movement within about 5 feet of the sensor. The fan duration at this setting is approximately 60 seconds.
Next we'll attach the filter support rods, the prismatic window plastic, and finally the activated carbon filter material. Almost done!

Using a fine-toothed saw, cut two 1/8 inch acrylic rods to a 2-5/8 inch length. Dry-fit the rods in the mounting holes and check for a proper fit; the rods should fully nestle into the u-shaped holes. Test that the front panel fits correctly with the rods in place. Use a small file to adjust the rod holes as needed. Place a very small drop of gel super glue in the bottom of each hole as shown. Do not put any glue in the front panel's rod holes.

Press the two rods into place and hold for 30 seconds until the glue sets. Allow the glue to cure for at least 15 minutes before handling.

Cut the 1/8 inch thick prismatic plastic sheet into a 1-3/4 by 2-1/4 inch rectangular window. Dry-fit the plastic window to the underside of the front panel to assure a proper fit. Apply a few very small dots of superglue or acrylic cement to the underside of the front panel in areas that won't show.
Press the smooth side of the plastic window in place against the underside of the front panel. Set aside until the glue cures.

Cut a single layer of the activated carbon filter material to the dimensions shown. Place the filter material over the large opening in the front panel. It should fit snugly. The acrylic rods will hold the filter in place when the front panel is attached to the enclosure.

After the glue has set, attach the front panel to the enclosure. Attach rubber feet on each of the two of the larger sides of the enclosure, two per side as shown. The feet keep the enclosure from slipping regardless of its left or right-handed orientation.
Charge and Use

The solder fume extractor's window will glow red if the battery needs charging. Plug a charging cable into the micro USB and watch as the window glows yellow to indicate the charging process. The window will glow green when the battery is fully charged. A fully depleted battery takes about one hour to recharge. If the extractor is running, then recharging will require more time.

Because the fan only turns on when needed, the solder fume extractor battery will easily last long enough for a typical two or three-hour soldering session -- with the lamp at medium brightness.

Remember, the extractor was designed for either left-handed or right-handed soldering. Just flip the enclosure end-for-end to point the motion detector to the other side.

The extractor will work best if it's kept close to the soldering action. Experiment with distance to maximize the absorption of those pesky fumes. Happy soldering!