

Circuit Building 101

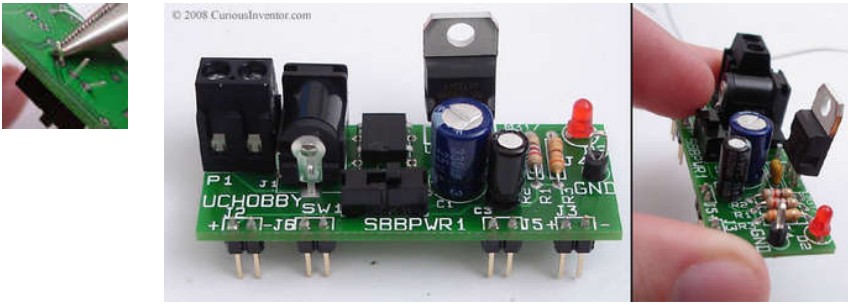
by [CuriousInventor.com](#) on February 23, 2008

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intro: Circuit Building 101

This is a beginner's guide to building circuits that will talk about the "proper" way to install components (resistors, ICs, capacitors, etc), and also a little bit about soldering. It'll cover things like recommended tools, how far and which direction components should be inserted, pre-bending and clinching leads along with some tips and tricks. We'll be using a **power supply kit** made by David at **uCHobby.com** that plugs into a bread board for demonstration. Yep, we're commercial and **sell** all this stuff, but the advice should apply equally well to anyone's tools and circuits.



step 1: Recommended Tools and Supplies

- **Soldering iron and solder:** Just about any 25-30 Watt soldering iron will do. Ideally, the temperature of you iron would be between 600-700 degrees F (for lead-free solder, 700-800 is recommended). How temperature relates to wattage depends a lot on the iron (watch a [video](#) testing the temperature of cheap RadioShack irons), and some high wattage irons have too high of a temperature. Avoid "solder guns" as these are meant for pipe soldering. Not only can these be too hot, but they work by running high current through a resistive heating element, and this could apply dangerous voltages to your circuit.

For solder, we recommend starting out with a lead-based solder, usually called 63/37 (63% tin, 37% lead by weight) or 60/40 rosin cored solder. Get whatever's cheaper; there's unnoticeable difference in hand soldering between 63/37 and 60/40. The rosin is a flux that cleans parts so solder will bond with them. Avoid solid wire (no flux core) and acid cored solder (for plumbing, too aggressive for circuits). We recommend solder that's about .031" in diameter for most through-hole components. Water-soluble flux is much more aggressive than rosin, and these residues must be cleaned. Lead-free solder melts at a higher temperature, and doesn't wet or spread out as readily, so it will be slightly harder to use.

- **Needle Nose Pliers:** Useful for pre-bending leads, pulling out components during de-soldering, and a lot of other things.

- **Wire Strippers:** Two types are shown: the yellow ones can be adjusted to strip any size wire (good for small 28-30 AWG ribbon cable wires) whereas the red handled ones have several fixed hole sizes.

- **Flush Cutters:** Used to trim leads close to the board after soldering .

- **Clamps:** Oftentimes just resting your board on a table will be fine, but the clamps are especially helpful when desoldering parts or soldering wires together.

- **Solder Sucker and Solder Wick:** Both are inexpensive ways to remove solder. The sucker is a spring loaded tube that vacuums out solder and the wick is a fine braid of flux coated copper that soaks up solder.

- **Multimeter:** Some multimeters have a continuity check that beeps if there is a complete circuit. This is very useful for making sure parts are connected or disconnected when there're a lot of wires and parts.

-**Pink Eraser:** (not shown) A pink eraser can be used to rub off oxides from older components and boards without risking damage to the parts.



step 2: What Order and Which Way to Insert Components

Most people advise to start with the shorter components first, and add more by height from there. This has two benefits:

- If there are tall components right next to shorter ones, you avoid having to bend already-installed taller components out of the way while inserting shorter ones later on.
- One of the best ways to hold a component in place is to insert it, and then lay the board upside down so the table surface keeps the component in place. If you install shortest to tallest, the tallest component will always be the one you're currently working on.

It's also helpful to install components so that the value can be read in the same direction as the surrounding text. For instance, install all the resistors with their tolerance bands on the right so that all the values can be read without having to rotate the board.

Make sure the notch on ICs matches the notch on the board.

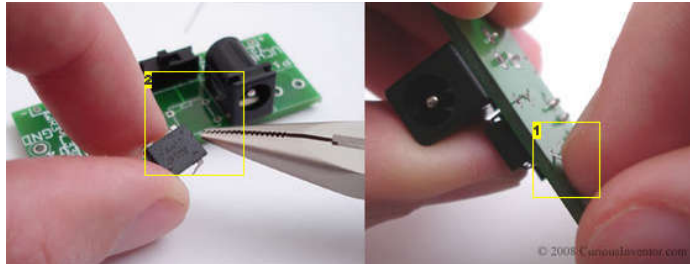


Image Notes

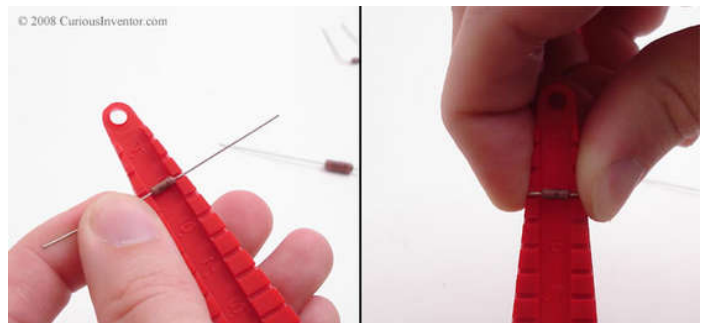
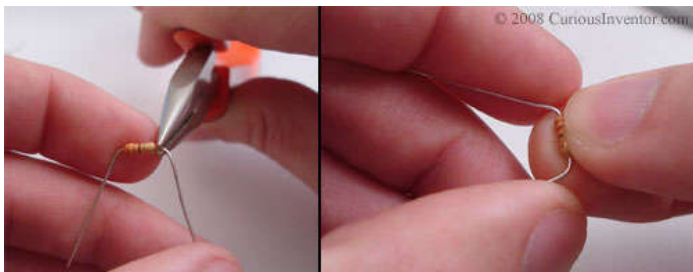
1. clinching by hand
2. make sure the notch on the chip lines up with the notch on the board. Pin 1 is to the left of this and the pins continue to count up going around counterclockwise.

step 3: Prebend Leads for Easy Insertion

To avoid stressing the holes and junction between the resistor body and its lead, pre-bend the leads before inserting the part. To do this, line up the resistor on its board location, grip the lead a little inside with needle nose pliers and then fold the lead over the pliers. The pliers prevent stress from reaching the connection point between body and lead. You can also use something called a christmas tree to quickly form both leads to the correct size.

Just fyi, for sensitive circuits (ie, military, space), serrated pliers aren't allowed because they might create a divot in the lead that could weaken and fail from vibration.

The "right" way aside, just bending the leads with fingers can work well, too



step 4: Clinch Leads to Hold Parts in Place While Soldering

Clinching means bending the lead slightly on the other side of the board to hold the part in place. For ICs, bend two opposite corners outwards.

The only downside is that parts can be harder to remove later. Other methods to hold things in place while you flip the board over include just having the table surface hold it in place, and also using tape. For instance, header pins can't be bent, so the table is used to hold them up in the last picture. You can also place some solder on one empty pad, and then reheat that pad while pressing the part through to get started.

In industrial manufacturing processes, parts are either held in place by a small drop of adhesive (for surface mount) or by clinching the leads. Boards are then transported via conveyor over molten fountains of solder (google wave soldering).

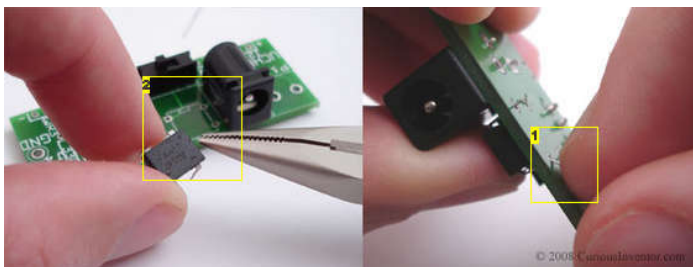
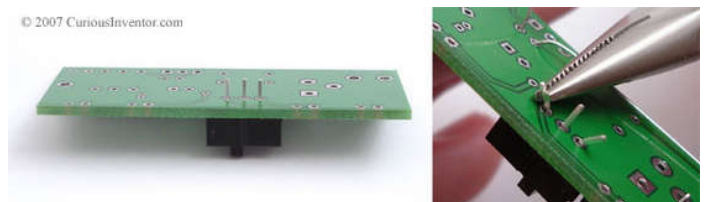
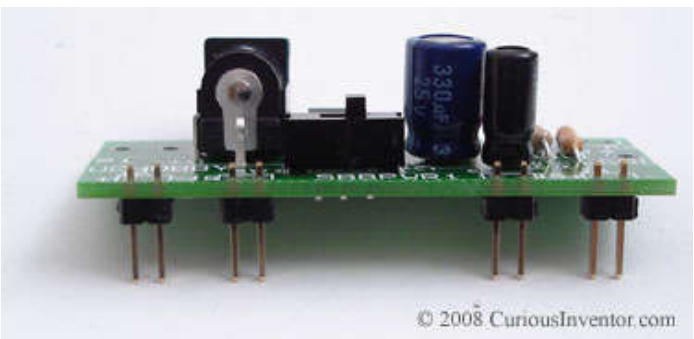
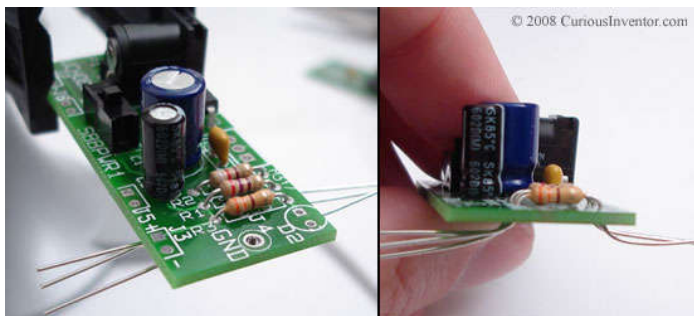


Image Notes

1. clinching by hand



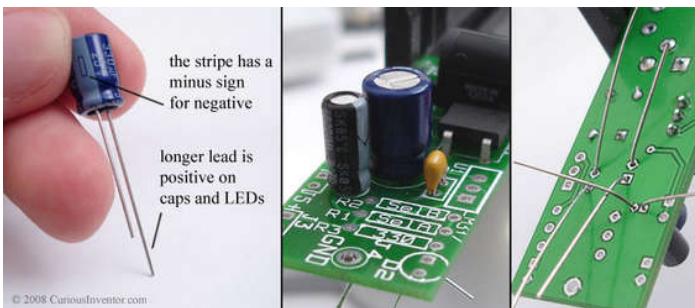
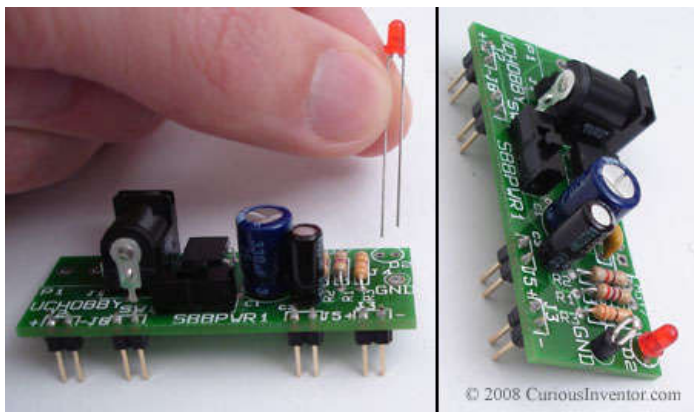
2. make sure the notch on the chip lines up with the notch on the board. Pin 1 is to the left of this and the pins continue to count up going around counterclockwise.



step 5: Make sure LEDs and Some Capacitors are Inserted in the Right Direction

The longer lead on electrolytic capacitors (the cylinder ones) and LEDs is positive. Insert most components until they lie flat on the board for extra stability unless they have a metal casing that could cause a short circuit.

it's OK if the yellow plastic on ceramic capacitors (disc shaped) goes beneath the top level of the board and touches the solder, it just can't show through to the other side (according to IPC, the industry's soldering standards organization).

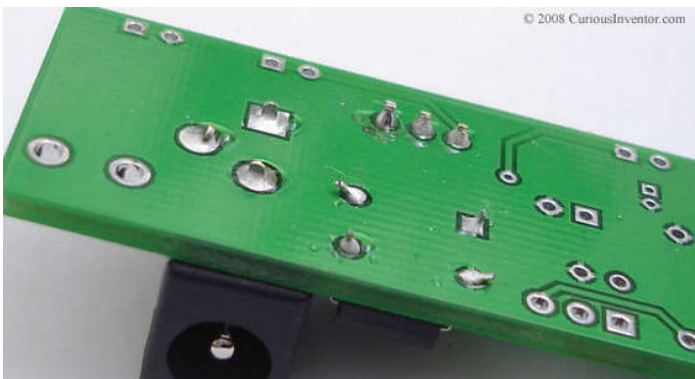
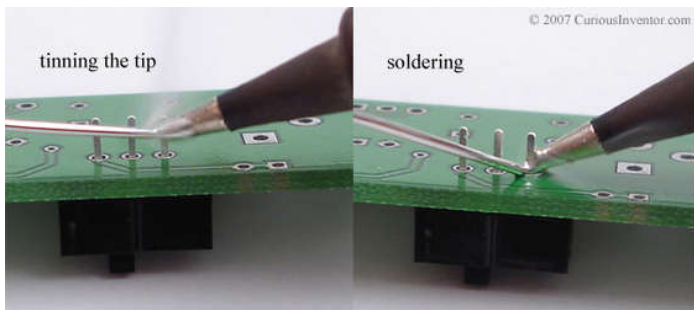


step 6: Soldering

You've probably heard that solder should melted on the parts and not the iron tip. The catch is that a dry tip will not transfer heat very well. You need to have a little solder, called a heat bridge, between the iron tip and parts. Do this by either melting a small amount of solder on the tip before soldering ("tinning" the tip) or adding some solder at the junction between tip and work. Then melt solder on the opposite. It should spread out towards the iron tip and heat. A video is available with many more details.

Usually people say that joints should come out looking shiny, but this is only true for lead-based solder. Lead-free joints will have a duller surface finish, but still be perfectly fine joints. With either type, the solder should cling to or wet the surfaces, and not just sit on top of them. It should form a smooth ramp and feather out across the pad. The above link also has some galleries of good and bad joints.

It's a good idea to check the part for correct alignment after soldering one pin. Adjustments can easily be made at this point by reheating that one pin, but once multiple pins have been soldering, the part may need to be completely removed to adjust it.



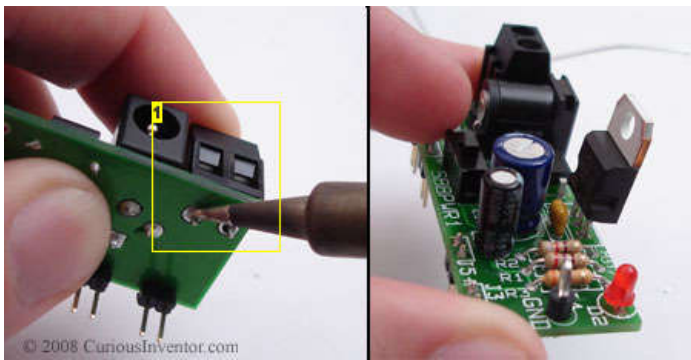
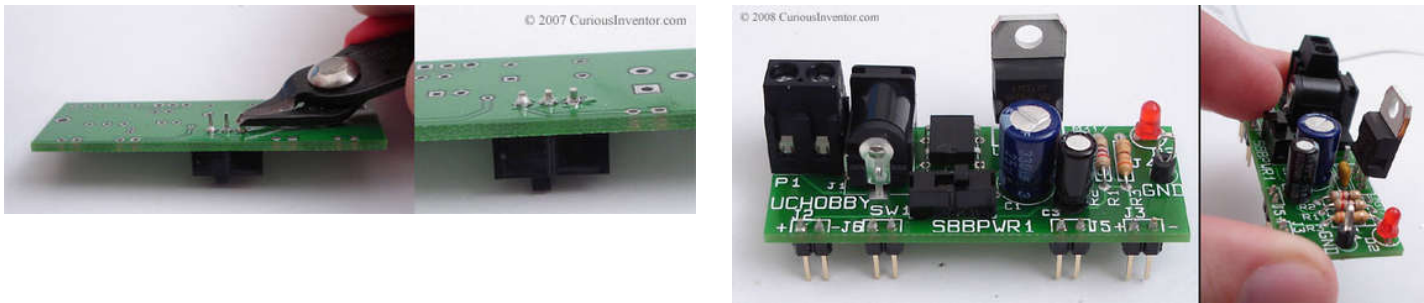


Image Notes

1. making an adjustment by re-heating one pin before soldering the 2nd

step 7: Trim the leads

Flush cutters are useful for trimming leads close to the surface. Regular diagonal cutters can work, also. Safety goggles are actually a good idea for this step as the leads can fly off quickly. We usually like to hold on to the lead while clipping.



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Comments

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Doom and Destruction says:

Jun 25, 2008. 6:33 PM [REPLY](#)

I am just getting in to this and i need help with it send me tips please.



feralbeagle says:

Mar 23, 2008. 2:06 PM [REPLY](#)

As an electrical engineer and someone who has taken soldering classes, I think that this is a very good guide for soldering. Oh, and an excellent choice of tools.

You may also want to check out sites of manufactures like Kester.
Kester Knowledge Base

Here is some info on lead-free hand soldering. (I have difficulty with most lead free solders because it does not wet well)
Lead Free Hand Soldering (the pdf link was broken, this one seems ok)

MIT also has some info:
<http://web.mit.edu/6.270/www/contestants/workshops/1-Soldering.pdf>

For folks who are starting out or who want to improve their skills, practice more. I think three weeks of class were spent soldering wires together, then having it inspected by the instructor, being rejected and starting over. That's a lot of rejection but eventually we all got it right. The best part of the class was learning what a good solder joint looks and feels like. It has helped me A LOT as an engineer.



Grady says:

Mar 10, 2008. 1:51 PM [REPLY](#)

I soldered for many years & used to teach soldering, in the 4-seconds - Step. 1st second, iron to connection; 2nd second - solder to connection ; 3rd second - Pull solder back; & 4th second - pull iron away. Do you think this is proper?



feralbeagle says:

Mar 23, 2008. 1:45 PM [REPLY](#)

4 seconds it too long for soldering circuits. 2 seconds is the maximum it should take to complete a solder joint. Here is a manual that is a little outdated but mostly valid:
<http://enr.nmsu.edu/~etti/fall97/electronics/solder.html>



CuriousInventor.com says:

Mar 11, 2008. 3:27 AM [REPLY](#)

That sounds like a good, quick summary to me. The only catch is that the pre-heating step may take more than a second if the tip is dry, parts are oxidized or the component is large or connected to a ground plane. I might emphasize the 1 second timing less than the results that should happen...

1. Heat the joint until solder will melt onto the joint (sometimes this takes a while, sometimes almost no time, especially if there's an effective solder heat bridge.
2. add enough solder to cover the pad
3. wait for the solder to wick throughout the connection
4. remove iron.

The 4 second method is definitely neater :)



Grady says:

Mar 11, 2008. 9:42 AM [REPLY](#)

Oh, I guess I forgot to tell you that I always had the trainees to clean, then tinn the tips with solder before starting, & to hold the soldering iron as if they were holding a pencil. We had Flux-Solder back then, & I know that the flux-less solder was a lot harder to work with, when it came out. This method of training was so simple that I hardly ever found someone who just couldn't solder, no matter what.



Prometheus says:

Mar 2, 2008. 11:22 PM [REPLY](#)

Just as a note from me with a lifetime of soldering experience, any electric iron is overrated, use a butane-powered one if possible. Also, the higher heat delivery is great for sensitive components like semiconductors as the process of cold-to-welded is much faster, reducing heat-transfer to the component.

Anyone soldering more than just wire joins should have a clip-on heatsink as a backup for tough joints.

Lastly, isolated electric irons do not have ANY leakage current, as they rely on heat-transfer to work. Never use an iron that requires an electrical connection be made because as little as 0.3V can destroy certain semiconductors. The ideal is using a gas-powered iron, and drawing the solder to the pin rather than just melting it around the pin.

Solder always runs for the heat, as if a desire to remain molten. You may need to tin your work to get proper heat transfer, but solder is generally fed opposite the iron, not into it.

And I think you mean 53/47, not 63/47....110% solder is hard to come by lol...

Just a few tips for the hobbyist



CuriousInventor.com says:

Mar 3, 2008. 1:39 AM [REPLY](#)

Could you elaborate on the cold-to-welded bit? I've never heard that all electric irons are overrated... it would seem that a good temperature controlled electric would be safer, as its heat delivery is throttled to maintain a given temperature. With a butane iron, is there any feedback control over the tip temperature?



Prometheus says:

Mar 3, 2008. 11:52 PM [REPLY](#)

"Cold-to-welded" is from when you first put the tip to the work, to when the joint has cooled solid. You want as little heat to make it up through the pins to the component as possible, so you want to heat the pin quickly, feed the solder in, and pull away before too much heat is absorbed by the pin and transferring it to the internals.

As an example, I can make a perfect solder joint to a TO-220 transistor pin in just about a second, or to a pin of a 24-pin DIP in half a second, without significantly heating the package itself. Practice makes perfect....



Prometheus says:

Mar 3, 2008. 11:45 PM [REPLY](#)

Electric irons, while some are good, do not fare well when it comes to a quick and clean joint, as they are often not hot enough to make that joint without heating the component as well. You want to come in hot and fast (but not too fast, or you will make a cold-solder joint).

With butane irons, you control the tip temperature by regulating fuel flow. The only disadvantage to butane irons is the exhaust vents in confined spaces.



CuriousInventor.com says:

Mar 9, 2008. 10:17 PM [REPLY](#)

This gets into a larger question I've been pondering for a while now... "How much temperature and heat do you want?" First, I think that an electric iron with sufficient wattage and temperature control should be just as good as a butane powered iron, and possibly better since the electric iron can regulate heat delivery to maintain a particular temperature. Unless I'm mistaken (and please point out if I am), a butane iron simply delivers a constant heat, so the tip temperature can vary significantly depending on how much heat is lost to the surrounding air and component / board. This comparison only applies to electric irons / stations with active temperature control; butanes may certainly be better in general than unregulated electric irons.

But back to the question... what would be an ideal heat delivery and / or temperature? So we want to heat the joint without heating the component or damaging the board...

As shown in this video, using a small 25 Watt iron on a large wire results in high temperatures far away from the end of the wire (where you don't want them), since most of the heat is "sucked" away before it actually goes into heating the end.

One thought is to use an extremely hot iron all the time, so you can get the connection above the melting point of solder before the heat has a chance to spread.

But this goes against the advice from a lot of reputable sources (IPC soldering instructors) I've heard stating that lower temperatures are almost always better. In fact, most high end soldering stations can be locked to prevent operators from using too high of a temperature.

I suppose every different situation would have it's own ideal heat / temperature...

One more thought: in industry, entire boards are elevated above the solder melting point for more than a minute or two as they travel through reflow ovens.



Itsgoofytime says:

Mar 9, 2008. 4:10 PM [REPLY](#)

Perhaps it is the wattage of the electric soldering iron you are using? A 15 watt is a waste, I like to use a 25-30 watt soldering iron, and I never get a dirty solder joint. Perhaps it is your method?



ac-dc says:

Feb 28, 2008. 4:40 PM [REPLY](#)

There is a noticeable difference between 63/47 and 60/40. 63/47 being eutectic is much easier to use because the part doesn't have to be held perfectly still while the solder goes through it's plastic stage while hardening.

Acid core is not too aggressive for circuits, in fact for aged parts it is the preferred solution but it absolutely must be completely cleaned off later. In fact, with today's lead free soldering the industry is using more aggressive fluxes than the old rosin core was, BUT for a hobbyist using new parts I agree rosin core (or no-clean, depending on the project requirements) would be the best choice for typical soldering.

Another *tool* to have is liquid flux. Usually, people apply too much solder to a joint just trying to get enough flux on to make it flow good. There are solders with 3% flux instead of 1 or 2% that will do better or using a separate liquid flux will be the best result. Liquid flux also is very handy when using desoldering braid, allowing excess solder to be removed more quickly and gently by reducing the amount of heat applied, even if the braid had a little flux in it already.

Solder guns do not apply dangerous voltages to a circuit. Not possible. They use an isolating transformer and very low (isolated) voltage. However they are too hot running for most hobbyist electronic work and yet for some jobs, there is no way a 25-30W iron would get the job done so either a heftier iron with stouter tip or a gun would be required.



Scurge says:

Mar 2, 2008. 8:41 AM [REPLY](#)

is the liquid flux you mention the same as the paste flux used in copper plumbing? I've not used it on actual parts, but i use it to "prime" de-solder wicks. I should also mention that when i don't have any desolder wick, i just use stranded speaker wire (14 or 18 Ga) twist the strands together loosely and smear a small amount of flux on the wire. it usually works almost as good as the braided wick. incidentally, it also works great to clean up poor solder joints in home plumbing.



CuriousInventor.com says:

Mar 2, 2008. 9:23 AM [REPLY](#)

The liquid flux we sell, or for that matter, any electronics flux is definitely not the same as the paste flux used in copper plumbing. Flux for plumbing is much more aggressive and, even if you attempt to clean it, any small portions that remain will continue to eat away at your board.

The aggressiveness of a flux is independent of it's form, whether paste or liquid. The two main choices for electronics are rosin-based (comes from pine sap, actually) and water-soluble (you can also call this an "acid" type). All water-soluble fluxes need to be cleaned with warm water to prevent corrosion, and are generally used for older / corroded parts. Rosin-based fluxes are generally less aggressive, which means it won't be able to remove as tough of oxides, but it will also be less likely to corrode the board later. There's a large range of rosin-based fluxes varying from "no-clean" types (although "no-clean" can apply to anything, it's more of an ad than a scientific standard) to very aggressive "activated" fluxes.

In the end, if it's water-soluble, you need to clean it, and if it's rosin-based, you need to know how aggressive it is to decide on cleaning.

Neat idea for home-brew wick.



ac-dc says:

Mar 2, 2008. 3:01 PM [REPLY](#)

The ideal homebrew flux for DIY hand soldering is rosin based. Essentially rosin dissolved in alcohol, perhaps some water and misc other things in it too. Circuit Specialists sells a 4 oz. bottle for example.

Industrial PCB manufacturing has often shifted to a water based flux because of RoHS, and because they can use a pressure hot water spray to remove it.

No-Clean is generally put in a solder but not so often desirable as a separate flux as the thing about adding flux is it can easily be removed later, excess isn't a problem, but with no-clean it takes special solvents to remove it and it isn't intended to be removed later being milder than average rosin core (due to being mostly non-hygroscopic) and esthetically neutral because it's fairly clean and colorless.



CuriousInventor.com says:

Feb 28, 2008. 6:36 PM [REPLY](#)

As far as I know, the main impetus to switch to 63/37 was for mass manufacturing of SMT devices, not easier hand soldering. Yep, 60/40 has a plastic state, but I personally have not experienced greater freezing time, more disturbed or cold joints, or significantly improved flow of 63/37 over 60/40. One thing that usually isn't mentioned when talking about eutectic alloys, is that a cup of water is eutectic (meaning it's all water or all ice above and below some temperature), but if you put it in the freezer, it doesn't all freeze instantaneously; rather, it freezes from the outside in. The question to answer is, "How much faster does complete freezing occur?" I wonder if anyone's ever done a blind study to see if people could guess which solder they were using. This isn't necessarily for you, ac-dc, but anyone else wading through these comments that wants to learn what eutectic means can visit that link (click expand after alloy, and then click expand again in the "Standard lead-based solder" section).

I could be wrong on this, but doesn't "acid-core" usually refer to copper pipe solder? I'm used to seeing "water-soluble" as the electronics version that is certainly safe to use if it's cleaned thoroughly.

Good stuff about using liquid flux with braid.

On solder guns, I guess the first question to answer is "How much voltage could damage a circuit?" The Weller WES51 brags about having a grounded tip with 2 mv RMS or less voltage, and also zero power switching. What kind of a circuit would be affected by, say, 5mV? 20mV? 1V? Certainly the solder guns don't have 120V at the end, but I'd bet it's in the single digits... correct me if that's off.



CuriousInventor.com says:

Mar 2, 2008. 9:26 AM [REPLY](#)

One thing I forgot to mention before about the solder guns:

Even if an isolation transformer is being used, isn't there some risk that the current would go through your parts instead of the resistive heating element? The ColdHeat brand soldering iron doesn't even have a heating element, you *have* to complete the circuit with your component (The tip is shaped like a fork).



ac-dc says:

Feb 28, 2008. 7:40 PM [REPLY](#)

If by impetus you mean simply that mass manufacturers are the majority using solder then yes, but it doesn't diminish the benefits of eutectic solder for DIYers hand soldering.

Acid-core refers to acid-core, it is not just "copper pipe" you can use on anything you want, including stained glass or due to it's more active nature, exceptionally corroded parts. The problem with it isn't so much the effect on the metal while soldering, as the solder does plate those parts but rather than when it's left on an area it just continues to slowly eat away at it so it must be cleaned off. Personally I find it very handy to use plumber's tinning flux to plate homemade PCBs, since it's readily available, the price is great, and I've never had a problem with it though I do clean off excess flux right after soldering.

A soldering gun does not have much voltage, single digit at most IF the tip weren't installed, but it is which pulls down the voltage to practically nothing relative to itself - but you are ignoring the important part - there is no circuit, it's not a voltage relative to anything on the work, only relative to an inaccessible point in the soldering gun itself.

With the resistive element being driven by secondary winding of a transformer, it's floating - the only way you would put current through the work is if you soldered a second wire to the inside of the soldering gun then touched that somewhere else on the work.



CuriousInventor.com says:

Feb 29, 2008. 4:15 AM [REPLY](#)

By impetus, I meant that (afaik) the motivation to switch was to achieve better yields on surface mount components being soldered with paste and reflow processes, not because the manufacturers use more solder. I believe they used 60/40 for a long time for standard through hole components without trouble. I fully admit to speculating here... but I'm still not convinced there is a noticeable difference in hand soldering.



ac-dc says:

Feb 29, 2008. 9:20 AM [REPLY](#)

It's not my burden to convince you of something that is fairly common knowledge among those who solder by hand a lot. I stated it because it is a fact, one you simply didn't know and now you resist learning something new.



fswanson says:

May 2, 2008. 1:33 PM [REPLY](#)

Why don't you just say I'm right your stupid. Or is it possible there are differing opinions on the best solder to use?



ac-dc says:

May 2, 2008. 4:35 PM [REPLY](#)

Were you hoping your comment would be constructive? It doesn't seem so.

Why would it matter if there are differing opinions on the best to use? There are different opinions on most things, and it doesn't matter. Opinion is irrelevant. What is relevant is accumulation of the details that matter for your project. Some of these might be:

- 1) Purchase cost
- 2) Availability - maybe you already have solder or there's a store a block away.
- 3) Compatibility with flux you might have or need (Or might not need)
- 4) Whether longevity (leaded) or pseudo-environmental concerns matter more.
- 5) Whether there is any valid reason to choose a solder that has a long plastic state like 60/40 does when cooling. Otherwise, that it does so can only have a negative consequence. In some solders you might find certain alloys that are eutectic at significantly higher melting point which can be detrimental in use on sensitive components, but that is not significant in 60/40 vs 63/37.
- 6) Further variables applicable to each project.
- 7) I didn't ask you to like my answer, but it is factually supported rather than opinion. It is common knowledge and you are welcome to Google search for this. When someone comes along and states something in contradiction to what has already been written, it tends to be for a reason, and it is then time to investigate further - I mean you do so, fswanson, so you have information instead of opinion.



AB1BE says:

Feb 29, 2008. 11:20 AM [REPLY](#)

Thanks for an excellent Instructable. Great info, well explained, good pictures and helpful video. I also appreciate the many useful references on your site. Thanks very much!

I'm very interested in AC-DC's comment "you might be surprised just how many pains some will go to in order to make a project look nice". I look forward to learning from the you gurus about how we can make our projects more professional.



ac-dc says:

Mar 1, 2008. 4:27 PM [REPLY](#)

It's a vague open ended request so it's not like there is some short list, but I'll give you one anyway!

- Enclosure: right size, good styling, attention to geometry when placing jacks on it. No ratshack, velleman, etc, plastic project cases or old steel industrial looking shells.
- PCB: Professionally made, silkscreened, rough-cut edges sanded down
- Wiring: Common color-coding as much as possible, trimmed to correct length, routed tastefully, twisted and often in heat-shrink or other tubing
- Capacitors with pretty, color matching or opposite contrast color scheme
- Extra fancy jacks, plugs, terminals, knobs, switches, etc. You'll know 'em when you see 'em.
- Opaque LEDs that aren't excessively bright for indicators.

- Custom artwork or signature on faceplate.
- Controls labeled on faceplate,
- Resistors with solid body color and text not stripes, like Vishay Dale RN series.

None of these things have any valid functional purpose, just beauty and often durability. Not all are worthwhile for some projects, and it depends on the individual how much it's worth in time or cost. Sometimes it's just nice to use the parts you have on hand and get a project done quick, even a bad looking project looks ok once stuffed into a nice case.



AB1BE says:

Mar 1, 2008. 8:29 PM [REPLY](#)

Thanks very much ac-dc! That's a great list. Fascinating. Thanks for taking the time to share these tips. An excellent starting point for those of us wanting to refine the appearance of our projects. I'll keep my eyes open for these finishing touches on any audiophile project sites that I find.



CuriousInventor.com says:

Mar 1, 2008. 7:09 AM [REPLY](#)

thanks! Hopefully AC-DC will make an instructable of his own about the looking-good part...



theprofessor says:

Mar 1, 2008. 11:00 AM [REPLY](#)

no lead solder should also look shiny, the myth that it wont is perpetuated by the fact that you need a hotter tip to melt it and most hobby irons are not hot enough to cause it to wick properly.



CuriousInventor.com says:

Mar 1, 2008. 11:58 AM [REPLY](#)

So you do in fact get shinny joints with lead-free solder? Could I ask what brand you're using and what the chemistry is? kester seems to claim their K100LD solder comes off looking shiny, but my experience with most flavors is that the joints do in fact look duller. I am also basing this assessment from the IPC-610 Inspection criteria, which you can fortunately see a [preview](#) for. Check out page 5.

There are several sites like <http://www.wiringharnessnews.com/Articles/1999/SOLDER/solder.HTM> that have similar comments about lead-free: "We will need to re-train our inspectors because the solder joints will look different. They will have a little more white in them; they will not be as bright and shiny, and we will not like what we see. The wet-ability and shape of the termination will look the same but the brilliance will be different."

In my testing, even cheap RadioShack 25W irons get hot enough, although you'll have to wait for a while in between joints for the tip to recover. Here's Kester's alloy temperature chart that shows a bunch of melting points for a variety of lead-free solders.

Please don't take this to be stubborn or argumentative, I'm just trying to provide references for my claims. It sounds like you've experienced / heard things differently, so I'd be interested in hearing the rationale / experience.



ac-dc says:

Mar 1, 2008. 4:15 PM [REPLY](#)

Lead free solder can certainly look shiney, it's shiney all over a computer motherboard I'm looking at. However, not all formulations are shiney even if heated hot enough, they tend to have a whiter hazy sort of look to them. With these, no amount of heating will make a difference.



millingabout says:

Feb 25, 2008. 11:37 AM [REPLY](#)

A properly installed resistor of this type should have a space between the circuit board and the resistor. Before soldering place a thick piece of paper between the resistor and the circuit board. Remove the paper after the parts are soldered. This is particularly important for resistors dissipating high wattage as resistors are designed to uniformly dissipate heat over the entire body of the resistor into the air. If the resistor presses up against the circuit board, the resistor can not uniformly dissipate the heat resulting in thermal stresses for both the circuit board and the resistor. Cinching leads might make it so the parts are held better while soldering, but the price of doing so is a sloppier solder joint and an even sloppier cut when it is time to trim the leads. When I have no choice but cinching leads, I keep the bends to about ten degrees.



CuriousInventor.com says:

Feb 28, 2008. 6:23 AM [REPLY](#)

I have to admit that the advice to install resistors completely flat was given based off an industry standard without much other rationale:

from ipc.org's IPC-HDBK-001, p. 88 (not free unfortunately):

"6.5.1.1 Axial-Leaded Components: Axial -leaded parts are to be mounted as specified on the approved assembly drawing, approximately parallel to the board surface. The component body should be in contact with the board. The furthest distance between the component and the board should not be more than 3 mm for Class 1 and 2 or .7 mm for Class 3."

Sounds like they're recommending laying resistors flat for mechanical reliability reasons unless the manufacturer specifically says clearance is required for air flow. I doubt the mechanical reliability and thermal requirements for hobby projects are tough enough that it really matters in most cases.

I'm not sure I agree that clinching results in a sloppier joint, but that's up for personal opinion. I'm fairly certain it leads to a stronger joint, and is actually required when the hole isn't plated. But this comes at the cost of much more difficult removal.

cheers



ac-dc says:

Feb 28, 2008. 4:20 PM [REPLY](#)

It is not important to leave space between the resistor and the board. With resistors rated at such a high heat density they have built-in kinks in the legs or standoffs. The important thing is to provide a margin for a resistor, say around 50%. For example if your resistor dissipates 0.8W you would choose a 2W, not 1W resistor.

The more important factor with resistors running very hot is that the copper on the board be of ample area so the heat conducted through the leads doesn't cause thermal stress/delamination to that copper trace.

As for cinching leads, the cut isn't substantially sloppier, the soldering will go fine still so long as one important element is in place: The solder has enough flux in it or flux is added (not 1% flux) because when it's cinched it tends to result in a smaller gap in the hole. I am speaking of plated hole joints, when it's a single-sided board without plated holes then cinched leads are always superior. The only reason industrial soldering doesn't do this typically is that it would be an extra step and there isn't usually a human flipping the board over to solder.

Removal isn't very difficult either way, providing a quality PCB is used and a quality PCB should always be the starting point for a quality assembly.



millingabout says:

Curious, ac-dc,
Thank you very much for your high quality follow up comments.

Mar 1, 2008. 3:59 PM [REPLY](#)



dickda says:

Nice tutorial. Sorry that you had to put up with an "expert" who obviously knows more than the rest of us...

Mar 1, 2008. 10:33 AM [REPLY](#)



CuriousInventor.com says:

thanks! AC-DC had lots of great points, we just seem to have had different experiences with two common types of solder (60/40 and 63/37)... I haven't been able to tell any difference in hand soldering, but I could very well be alone on this.

Mar 1, 2008. 12:03 PM [REPLY](#)



spry981 says:

I have found that using a small fingernail clipper works quite well for most lead trimming. It's small and easy to maneuver when you have a lot of leads sticking up.

Mar 1, 2008. 6:24 AM [REPLY](#)

Of course, safety glasses are a must!



ac-dc says:

Something I seldom see mentioned is that with jacks, plugs, switches that are subject to stress from external user, use, it can be helpful not only to cinch the leads but also manually hold the part against the board tightly while soldering. Eliminating even the very last little bit of play can make the part much more resistant to twisting back and forth later in use. In extreme cases I've even put down a bead of epoxy around jacks and/or during repair work where the aforementioned stress had pulled up a jack or damaged the traces. It is uglier looking to put down the epoxy but which is worse, ugly or broken? For really high stress uses a panel mount jack, switch or plug is really the only way to go without switching to special expensive parts.

Feb 28, 2008. 4:49 PM [REPLY](#)



CuriousInventor.com says:

Parts are routinely held down with epoxy in automated manufacturing (for instance, to keep SMDs in place for wave soldering), I don't think you lose any points for adding extra.

Feb 28, 2008. 6:41 PM [REPLY](#)



ac-dc says:

That's hidden under the part. I do a lot of audiophile projects, you might be surprised just how many pains some will go to in order to make a project look nice regardless of whether it's functionally any better or not.

Feb 28, 2008. 7:44 PM [REPLY](#)



ac-dc says:

I think there should be a step 8: Cleanup.

Feb 28, 2008. 5:00 PM [REPLY](#)

Assuming use of rosin core solder, take some alcohol (100% pure is nice, but a tiny bit of water won't hurt *most* components) and a toothbrush/etc and scrub off the excess flux. This also helps to remove stray solder balls, especially if solder paste was used. Next after scrubbing, rinse with alcohol and hang dry. Some people prefer to do the bulk of the cleaning before adding certain parts with inner cavities like POTS or switches, so they don't have to be as concerned about the flux and alcohol getting inside where it may wash away grease or take longer to dry (but a quick scrub with only a little alcohol and quick rinse and shake will not get much alcohol inside, I've never had a problem doing it in moderation).

If one were to use the (some would call ill-advised) acid core solders, then instead of the alcohol scrub a strong warm detergent water solution would be used, then rinsed with water, shook off, and ideally final rinse with alcohol and shook off again. Note that the industry doesn't usually follow with the alcohol but in some cases it means close inspection of a PCB you would find a hazy film still on it which is generally not a problem but many DIYers want their end result to look prettier than a retail PCB would be.



CuriousInventor.com says:

I'll add a step sometime soon... the only bit I would add is that it's easier to clean rosin based residues sooner than later. That being said, I'm not convinced cleaning is necessary for most rosin-based fluxes (Kester's datasheet for aggressive RA flux says even it doesn't need to be cleaned) for hobby projects.

Feb 28, 2008. 6:44 PM [REPLY](#)



ac-dc says:

Agreed, mildly activated doesn't need cleaned, but more active rosin like Kester SP-44 will turn gummy with a fair amount of ambient humidity which is unsightly and a tiny bit more active.

Feb 28, 2008. 7:43 PM [REPLY](#)

We also need to consider that hobby project can mean a lot of different things. Are hobbyists prevented from working with high speed fine pitched components? Maybe Kester assumes so but I'm not going to ask for permission?



ac-dc says:

Feb 28, 2008. 4:44 PM [REPLY](#)

For practical purposes, bending the leads as shown will work ok, but the best way to do this is to grasp the body of the part with your fingers but not the lead (leaves oil from fingers on it), instead bending the lead with wider, non-serrated duck bill pliers. This not only preserves the lead better but creates a nicer very straight and uniform lead. Again, for practical purposes it may not matter but if you have the duck bill pliers or are looking for tools to buy, it's a better result.



CuriousInventor.com says:

Feb 28, 2008. 6:38 PM [REPLY](#)

Just to add to the "proper" fire, the most important thing (according to the IPC standards) is making sure the resistor-lead junction isn't stressed. They recommend holding the lead with pliers in between the bend and the body.



ac-dc says:

Feb 28, 2008. 4:31 PM [REPLY](#)

It is preferred not to use serrated tooth pliers, they have the potential to deform leads more and flake off small bits of the tin plating which in rare cases can deposit on tight pitched leads and cause shorts. They can also accumulate bits of the flakes in their teeth which mash together and flake off as larger pieces. Granted it usually won't be a problem but if we're being "proper"...



CuriousInventor.com says:

Feb 28, 2008. 6:10 PM [REPLY](#)

To add to the obsessively "proper" list, I'm fairly certain serrated pliers aren't even allowed in high-reliability manufacturing. The reasoning I've heard, which you hit on, is that the teeth can make small nicks in the leads that eventually cause the part to fail after a lot of vibration or expansion and contraction from temperature change. On to the next comments...



ac-dc says:

Feb 28, 2008. 4:53 PM [REPLY](#)

I usually prefer thin-nosed very small diagonal cutters because you don't then have to focus on how far away from the board you're holding them, instead they automatically make a consistent ~ 1.3mm length to the leads by just holding them against the board. Of course with some parts the leads are too closely spaced to do this but usually not.



ac-dc says:

Feb 28, 2008. 4:51 PM [REPLY](#)

One mistake I often see people make is removing the soldering iron tip the moment it looks like the solder had wicked into the joint. Granted, some parts are especially heat sensitive but cooking the joint just a slight bit longer than the moment of wicking action will be far less likely to result in only partial or cold joints.



Tobita says:

Feb 26, 2008. 6:56 PM [REPLY](#)

Also, lead free solder doesn't seem to work as well as leaded solder as in they become more brittle and crack more easily.

[view all 65 comments](#)