Step by step practical guide for winding your own "Halo" Inductor

Written for Small Bear Electronics (www.smallbearelec.com) by Tom K. (Arteffect)

Everyone who uses a wah pedal heard about the early Vox pedals, they are considered to be the holy grail of wah tone. I won't go into a deep analysis of the key components inside a wah that add up for obtaining "THAT" sound, rather I'll focus on the creation of one of those key components - The inductor.
You might want to read this article from R.G. Keen's site to learn a bit more about the technology behind wah pedals.

You might notice the title says "practical guide", this means I won't go into any theory or equations (Google exists for that). I will try to write this guide as simple as possible so anyone who got the right parts and a little spare time could make a lovely sounding inductor that will change the way his wah sounds forever, even without understanding much about the electrical aspect of the wah pedal or the inductor.

A few words about the halo inductors: They were introduced to the world in 1967 inside Vox wah pedals. They had two types: small hole core and large hole core. The halos had the "magical" 500mH - 520mH inductance value which is believed by many to be THE key element in making the early Vox wahs sound the way they did. They got the "halo" nickname because of the ring they had on top of them (see picture).
Over the years these pedals became rare and pricey and a vintage Vox wah could run for over $700 which is too much for most people who are not full time rock stars.

Changing the inductor in you wah (Vox or Dunlop) won't make your pedal sound like a Clyde McCoy wah (early Vox) but it will get you closer, much closer!

I would like to thank paul from gaussmarkov.net for the 3D drawings of the inductor!

PLEASE READ THE ENTIRE GUIDE BEFORE STARTING AS SOME DETAILS WILL BECOME CLEAR ONLY AFTER YOU HAVE COMPLETED THE READING!

Here is a list of what we'll use for making the inductor:

(1) Inductor core set and mounting assembly (Get it at www.smallbearelec.com)
(2) 38AWG copper wire (www.smallbearelec.com)
(3) Scotch Mounting Squares (1 pack got 16 squares)
(4) Sticky Tape
(5) DMM with inductance measuring capability (Get this one from www.elexp.com) or search for one on eBay.
(6) Soldering station or soldering gun (I use Weller WES51 temp. controlled)
(7) 1" square of sanding paper

Optional:

(8) Home made winding assembly (More on this later)
(9) Digital counter and micro reed switch (Counter kit available from www.ozitronics.com)
(10) COOKIES! (Because they are SO good)

Coil Winding In Short

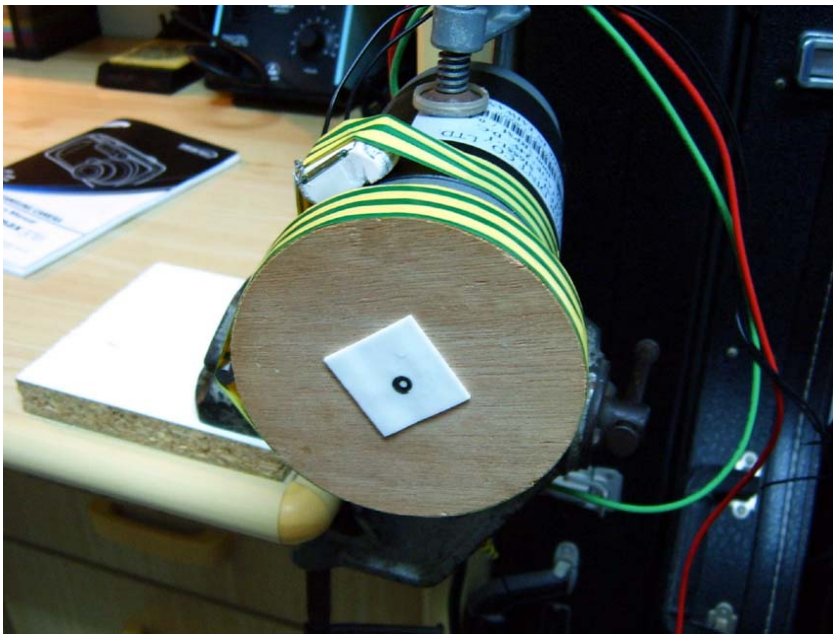
If you ever looked at a factory made inductor or transformer most chances it looked very neat and clean with the "wire tracks" going side by side. A machine can wind coils to be 99.999% the same each and every time, however when you will wind your own coil at home it won't be like this. Even if you have moderately good equipment it's very hard to

keep the thin wire feeding in a way that the winding will be "ideal". The good news is that you don't need to do that anyway!
In general, the more neat the coil is (= less wires crossing) the higher it's inductance is. You might think that if you won't wind a neat coil you'll end up with an inductor with a too low value, don't worry too much as the cores have a high value and we will actually have to adjust them in one of the next few steps to lower the overall inductance to fit into our desired specifications.

Don't wind the ugliest coil you can, try to keep it neat and avoid loose wire as this might cause trouble when playing loud with the wah pedal.

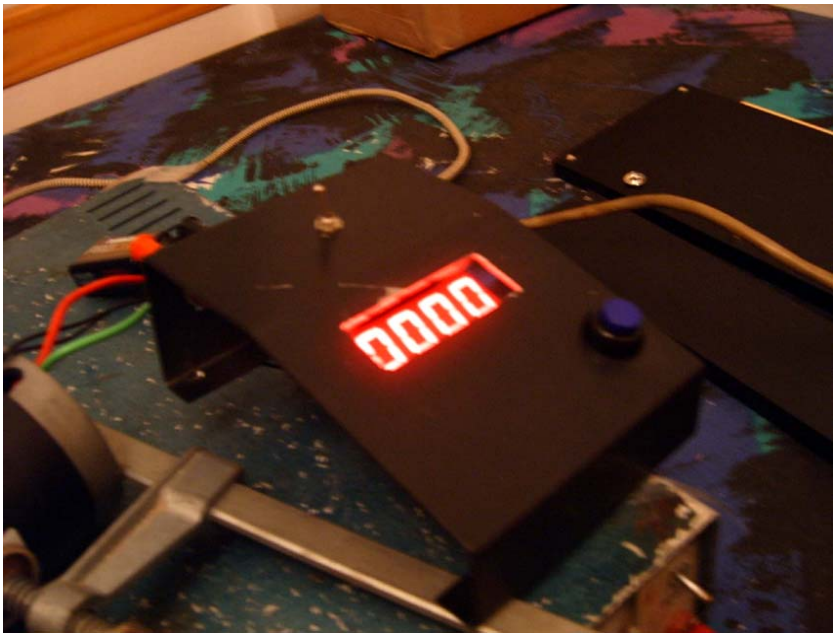
Winding Assembly

I made a very simple but accurate assembly for my own use. The wire is fed by hand and that is exactly the way you would want it to be done when making a small coil like ours.
I assume that not everyone will have the same setup at home so be creative and come up with something of your own, it's not hard at all. Even a drill mounted on a table could do the job! I will write the guide assuming you have a rig like mine, but even if you don't, things will work pretty much the same.



It can hypnotize you while winding!!!

This is a simple 24V DC motor, capable of doing 4000 RPM with no load, it's connected to a bench power supply. I'm able to control the speed by adjusting the voltage. The motor is clamped down to the edge of the table where I have the largest space for hand movement. I had some old wood around and I cut a circle out of it and mounted it on top of the motor's shaft. I made sure it turns evenly and that it doesn't wiggle. That ugly looking tape is there for a reason, it holds down a small magnet which I pulled out from an old guitar pickup. Why a magnet? To close the micro reed switch mounted behind the wood base (you can see it in the picture). The switch is connected to a digital counter, this makes life very easy!
You would have to use some kind of technique to measure the turns; multiplying RPM with how many minutes you wind would save you the expense of buying a counter but it's not that accurate at a higher speed. A counter kit is not expensive and might have many other uses as well so consider buying one.



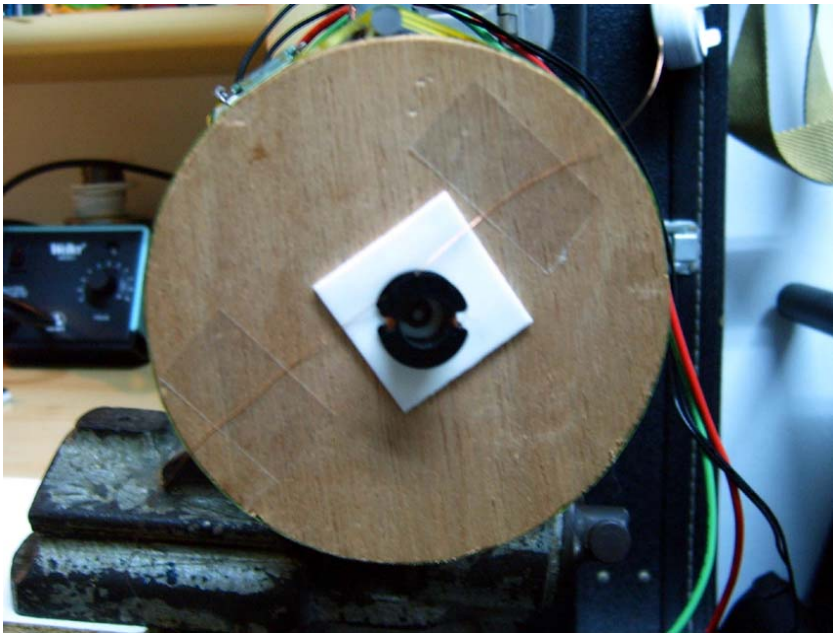
It had a nice looking box, but I lost it...

Notice the sticky square in the middle of the base, that is where the bobbin will be mounted. I run the motor slowly and take a pen and hold it in place as close to the middle as I can. This draws a circle (unless you are really good and it will mark a dot) which helps visualize things when I mount the bobbin. Always try mounting the bobbin as centered as possible so it won't move too much to the sides while you wind the coil. Keeping the same tension on the wire is the best way to minimize unwanted gaps in the coil.

Winding (While Having a Cookie!)

Your spool of wire may sit comfortably on the floor or at any other spot where the wire comes off easily, this is very important!
Make sure that the wire is fed without any obstacles. I usually place my spool on the floor. At the beginning the wire would get caught up on the edge of the bobbin so I sanded the edges with 1000 grit sandpaper and now it runs smoothly.

Lets start... Take the lead of the copper wire and run it over the middle of the sticky square, now tape down the wire to the edge of the base and leave about 1" of wire. On top of the wire, mount the bobbin (make sure it's centered). Start winding (by turning the wooden base by hand) and feeding the wire with your other hand, do this for 20 or so turns until you feel the wire has a good grip on the bobbin (start winding at one of the "cut-ins" of the bobbin).
Some people like to apply a little see-through nail polish or adhesive spray on the first coat to make sure the coil won't move anywhere, I don't do that. I think the bobbin holds the wire pretty well by it's own after 10 or 20 turns, so why bother?
When I feel the wire has a good grip on the bobbin I switch on the power supply and turn the potentiometer until the motor starts turning slowly, I will increase the speed to a point where I feel I have good control over the wire and that it's not getting loose on the bobbin. Loose wire will create gaps which are a no no!
Basically you keep on doing this until you reach the desirable amount of turns, then, cut the wire and tape the other lead to the base.



Completed coil. Leads are taped down.

Checking The Resistance

For our needs the resistance range is 29 - 33 Ohms. How many turns do you actually need to have on the bobbin? I don't know!
You should start with 550 turns and check for resistance by sanding down the insulation on the edges of the wires and use a DMM to determine the correct value. 550 turns is probably a little too high, so remove about 10 turns of wire and check again.
Do this until you are within the range I stated above. Don't get too caught up upon numbers, If you get 28.92 Ohm don't throw away the coil and start over.

When you are happy with the resistance value, tape the leads down to the base.
Now, take a short break to eat of of those yummy cookies you prepared earlier!

Potting The Coil & Putting The Assembly Together

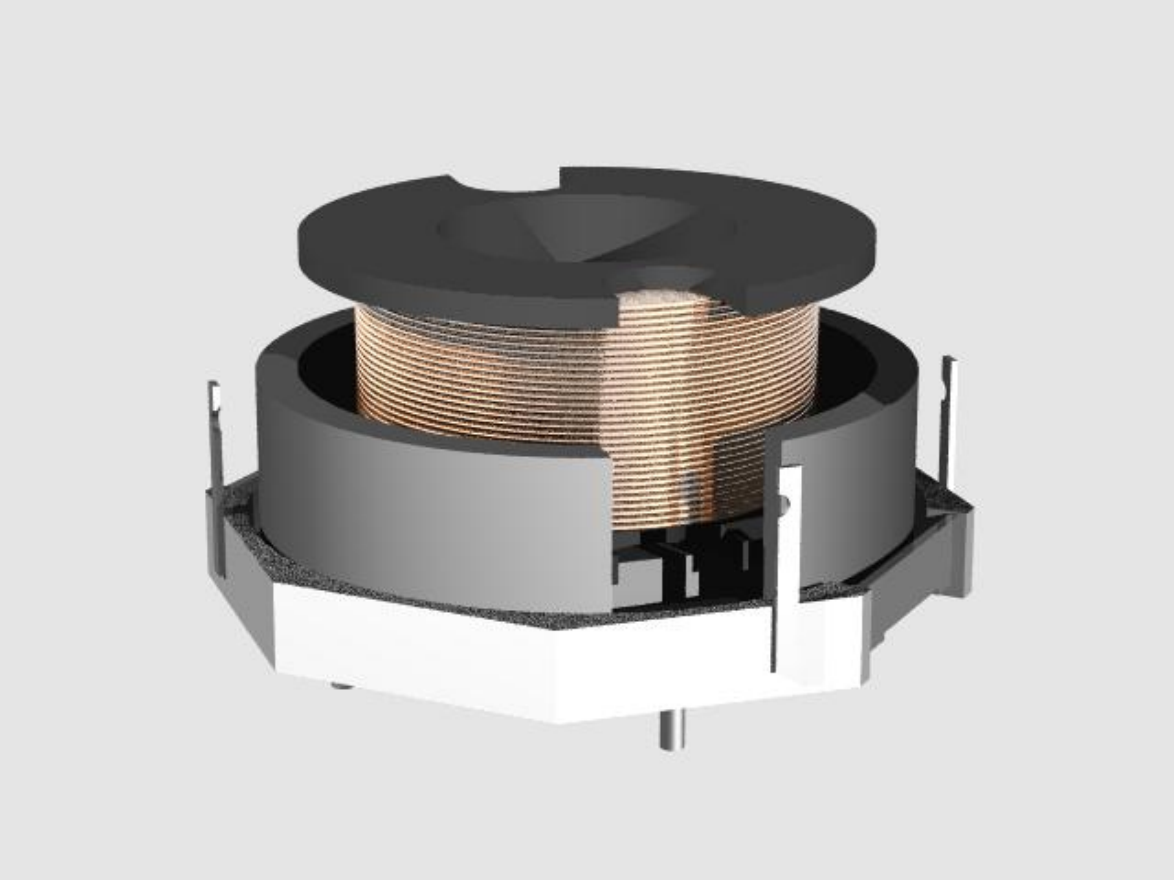
Potting will keep the coil intact so it will reserve it's inductance value over time (= coil won't move). You can pot in many different ways and I think all of them will work well for such a small coil. Artificial (or real) beeswax seems to be popular but I don't mess around with it because you have to melt it and it leaves too much mess to clean. See-through nail polish is actually great but won't appeal to many people because it's not "professional" enough (but it totally works).

I use liquid polyester. If you want to use it too, make sure you read all the safety instructions and that you work in a well ventilated room (if you have a balcony or a yard that would be the best).

Right now the bobbin should be mounted on the wooden base with both leads taped down. Using a toothpick, apply one drop of polyester to the coil. Work it around using the toothpick, apply as many drops as needed to cover the bobbin around (usually not more than 10 drops).
Be careful not to leak the polyester on the wooden base, you don't want the entire assembly sticking to it, right?
Turn on the power supply and using the potentiometer set a very low speed and let the entire thing spin for 5 to 10 minutes. You will see that the polyester will be sucked into the coil and because it turns all the time it won't leak to any edge (now how clever is that?!?). The polyester hardens slowly without an accelerator which is good in our case. You

will see that it holds the coil together while not being rock hard, not yet anyway.
Leave the bobbin at a well ventilated room (not a room someone sleeps in) or even better outside a window for the 24 hours to harden, you can also use a toothpick to drop a few drops of polyester bonding accelerator which will make it solid faster. The best place you can put the bobbin is a warm place because it will dry faster.

After the polyester is pretty much hard (and the core is in it's final form) take the bobbin and install it into the core assembly, here are the steps you need to follow:
1. Take the plastic base and put the circle washer on it.
2. Place one of the cores on top of the base.
3. Place the bobbin on the core and wrap the leads (through the gaps) on two of the small pins on the side.
4. Solder the leads to the pins (gently!). If your wire is covered with a solderable coating you won't have to worry if the leads are covered or not,
however it it's a non-solderable insulation you'll need to remove it using sanding paper otherwise you won't be able to solder.
5. Place the second half of the core on top of the first one with the bobbin between them.
6. Take the mounting ring, notice that the two "hooks" are not the same and one of them is smaller. Take a look at the plastic base and see that it's
hooks are also not the same and that one is also smaller. You can figure out which goes where, after you did that, hook up the side WITHOUT the
grounding pin and while holding the entire assembly together turn it over and place it on it's "back" with the soldering legs of the base
pointing up.
7. Press down firmly so the other hook will lock into place.
8. Adjust the ring so it will be in the middle of the top core and the two core parts so they will sit EXACTLY one on top of the other. This is very
impotent because if they don't, the inductor won't have it's max potential value.



The bobbin installed on half of the core on the plastic base. gaussmarkov.net

Exploded view of the entire inductor assembly. gaussmarkov.net

If you would like to secure the final structure of the inductor and perhaps pot the coil itself if you didn't already, you might consider using a mixture of beeswax (artificial or real) and paraffin wax as potting solution. Getting the right mix is not too hard and I would suggest starting out with about 70/30 ratio beeswax/paraffin. You will need to warm the wax until it melts, but be careful not to get it too hot! You can find good information about potting online and I rather not go into a lengthy description of the procedure as it might as long as this guide.

Final Adjustments

Now that your inductor is assembled, take a DMM and measure the inductance. You will notice it is higher than 520mH, don't worry this is fine!
Take the inductor apart and using the small square of sanding paper, sand down very little of the middle of one of the cores. I can't stress this enough - Take very little off of one ferrite core's middle, just enough so it will show on the sanding paper. Now, reassemble the core and measure it's inductance again. You will notice the value dropped down quite a bit. If you need to lower the inductance a little more, repeat this step until you are happy with the results. Be very careful - it's easy to take too much off and than you'll have to make a new coil with more wire on it to reach 500 - 520mH (so you'll have the right inductance value but not the right resistance value, although the inductor will probably sound very good anyway).

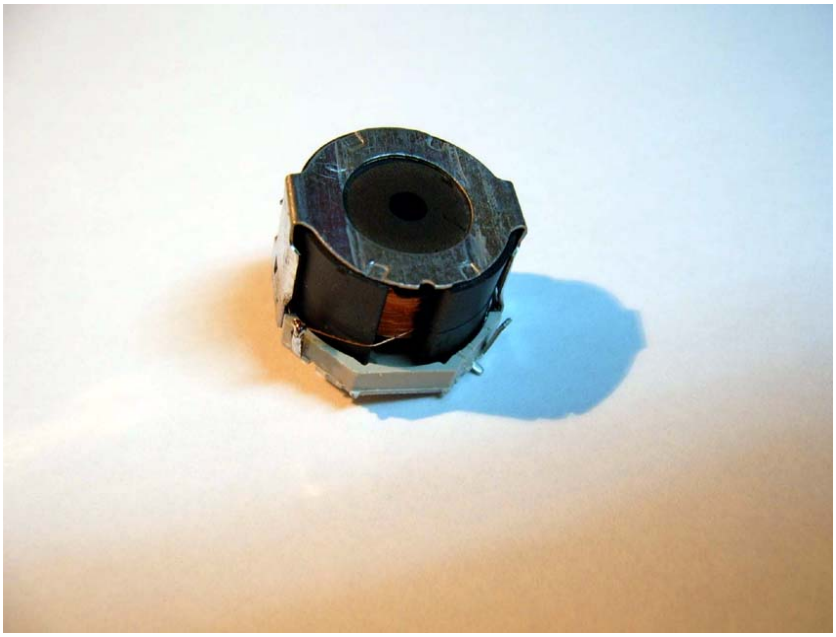
In case you took a little too much off the core and when checking for inductance you get 480 - 490mH don't worry because that value will raise a little bit in the next 24hours, while all the parts are adjusting to the pressure of the clamping ring.

After you are happy with the results you might want to remove the two extra solder legs on the bottom of the inductor, you only need two to mount it inside a wah circuit. While at it, bend the ground pin from the clamping ring inside or cut it off

This is the big moment!

Perfect!

520mH! What a number huh? Exactly that same value as the first halos!
This inductor is ready for installation in your wah... Solder it in and let the good times roll!



Let's work on that Voodoo Child riff, shell we?

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