The BNC Portable HF Loading Coil

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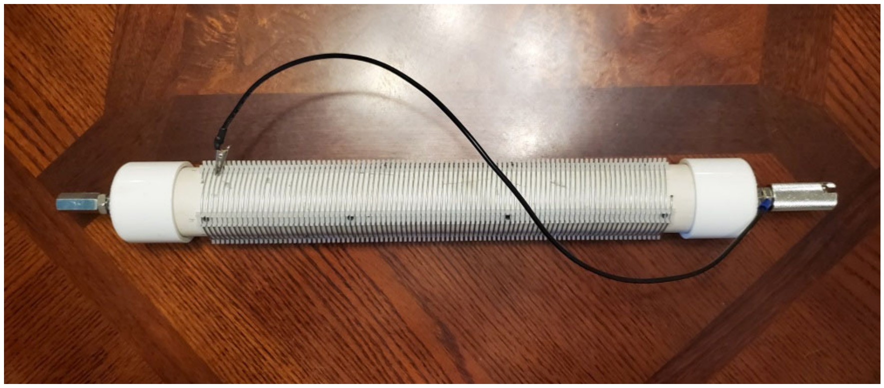


One of the things I love about amateur radio is the ability to build, modify, repair, and design your own equipment. For me, it's antennas. Of the dozens I have, I have only purchased two production antennas; a dual band for the 2/70 in my pickup, and a base loaded 80-10 meter portable vertical antenna.

I really enjoy setting up and operating my HF radio portable in the mountains here in Colorado and neighboring Wyoming, especially when camping. I can safely say I operate portable more often than I do from my QTH! That led me to find the Parks on the Air program, or POTA (pota.app/#/), where we set up our radio at designated national and state/provincial level parks (around the globe!) and "active" the park by making at least 10 contacts using all modes and bands of amateur radio. This activity leads to some very creative thinking by operators in terms of radio selection, battery and other alternative power sources, and of course, effective antennas. Note I did not use the term efficient, but rather, effective. While some activators have no issues with erecting a full size, very efficient 40 meter dipole, others wish to keep their footprint a little smaller, or the overall weight of their kit lighter.

For me, I want an antenna system that is effective, have multi band capability without the need for a tuner, rather quick and easy to set up and take down, and use minimal supporting structures to erect. So my antenna arsenal contains a linked dipole, various end fed half wave wire antennas, end fed random length wire antennas, various ratios of transformers, a couple different length extendable fiber masts, and the aforementioned portable vertical. While the vertical has its own tripod, I welded up a hitch mount that uses a 3/8"-24 x SO239 connection to which I added quick-disconnect mounts to. With that, I can install the hitch mount before I leave the house, and once at the location I intend to operate from I simply attach the whip to the coil, add a 3' extension under the coil, and attach the whip/coil/extension combo to the hitch mount. Run coax from the antenna into the truck, and I'm ready to start calling CQ! Tuning of this coil can be a little finicky at times, and initially changing bands took some time. So, I figured I could build my own and have it do exactly all the things I wanted it to do.

When I set out to build a widget, whether it's an antenna, farm implement, hot rod, or whatever, my process is usually the same: study several different widgets, note the things I like most about each widget, then combine all those things into my own version of the widget. A few of the things I wanted for my own coil was: a quick and easy way to change and tune through the bands; allow me to tune from 80 meters and up using a 102" whip; be able to operate on digital modes at full duty cycle using 100 watts (not that I do this, but for me it was a "requirement" for the design), lightweight but strong; easy to build with mostly hardware store items; and be inexpensive.

What I ended up with has been dubbed the BNC Coil. It checks all my boxes, and whether it's the current SFI numbers or not, I have set my own personal records for number of POTA contacts while using this coil, and its little brother, the BNC V.2 Coil. With that, I will detail as much as possible what parts I used, where to get some of them, and the steps to assemble your own. Once you have all the parts, this antenna can be assembled in just a couple hours. Other than a couple things that you will initially have to buy more than what you need for just one coil, your total cost when figuring "price per each" will only be around $20! With this in mind, this could be a great club project, make an extra for a friend, or just to have another one as a spare.

<u>Parts list:</u>

12"	*1-1/4" Sch 40 PVC pipe
4	** Wire traps, .135" pitch, about 8 TPI
48"	*** ¼" wide 3M double sided adhesive tape
2	1-1/4" PVC end caps, center drilled to 3/8", ends filed/machined flat for a flat washer
2	3/8"-24 x 1-1/4" SS bolts
4	3/8"-24 SS jam nuts
1	3/8"-24 coupling nut
2	3/8" SS flat washers
2	3/8" SS split lock washers
60'	**** 18 gauge galvanized steel wire
18"	16 gauge (minimum) stranded wire, 18" length
1	Small alligator clip
1	3/8" x 16 gauge ring terminal
2	¼" long sheet metal screws

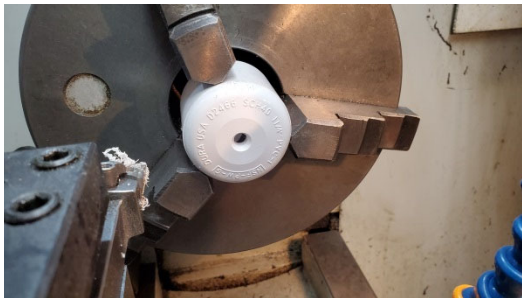
* Home Depot and Lowes sells these in 24" lengths, enough to make an 8010 *AND* a 6010 coil.

** McMaster-Carr, part number 85085K4. Package of 25 for about $20 shipped.

*** This is just one method. Use small screws, clear RTV, super glue, etc. It's up to you and what you have available.

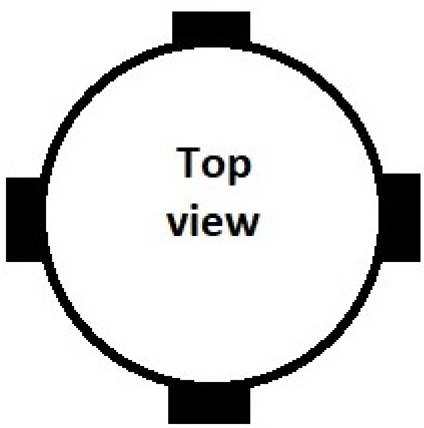
**** I haven't actually measured how much wire I used, but all of my coil calculators say 55-56 feet for the 8010 coil. I believe them. :)

First, decide if you want to make an 80 through 10 meter coil, or a 60 through 10 meter coil. For the 8010 coil, cut a piece of PVC pipe to 16-1/4” For the 6010 coil, cut the pipe to 9-1/4” For this paper, I will demonstrate an 8010 coil. To start, we’ll prepare the end caps. If you are lucky and have access to a vertical mill, or a lathe, you can lightly machine the raised lettering or logo off the ends of the caps so when assembled, the washer will sit flat on the cap. Otherwise, a hand file and a few minutes of careful filing to be sure it is flat and level will certainly do the job! Once flat, measure to find the center of the cap and drill a 3/8” hole. Insert a bolt from the inside of the cap, then install a flat washer, then a lock washer, then one jam nut, and tighten everything down. Next, close to the edge of the flat washer, drill a single 1/16” hole for the wire the exit the cap through. Do this for each cap.



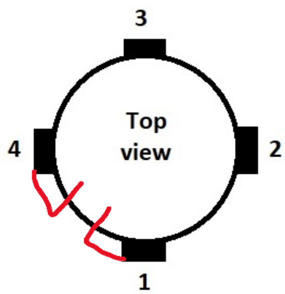
Bolt first, then flat washer,
lock nut, then jam nut.

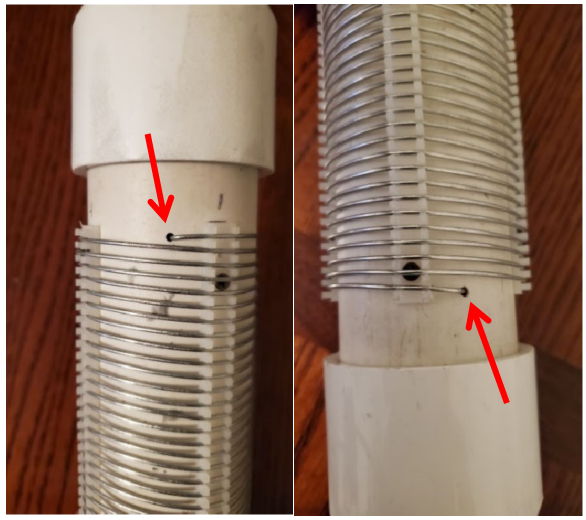
On one end of the pipe, make a mark at 1-1/2” from the end. If you have some masking tape or blue painters’ tape, run a strip of tape around the mark so that the tape is on the side of the mark closest to the end of the pipe. On the tape, make 4 marks that are 90° apart from each other, so you end up with 2 sets of opposing marks. This will be where we install the wire traps.



For an 8010 coil, you will use a full strip of the wire trap. For a 6010 coil, each strip will need to be cut to 6-1/4” long. Using whatever method of attaching the traps you chose, install the first one with the end of the strip touching your tape/mark. Make a mark so you know this is the #1 strip. Going counter-clockwise, install the second strip just even so slightly lower than the first, about 1/32”, and attach it. For the third, install it 1/16” down from the tape/mark. Install the last strip 3/32” down from the mark. Staggering them like this will allow you to wind the wire onto the strips and have them coil nicely around the pipe with no jagged offsets.

While holding the pipe with the #1 strip facing you, and the top of the pipe facing up, make a mark ½” to the left of top set of fingers on the strip. Hold the pipe in the same orientation, make a mark ½” to the right of the #4 strip.





To start winding the coil, push the wire through the hole left of the #1 strip from the outside of the pipe, to the inside, and pull enough wire through so that 4” of wire extends out the end of the pipe. Begin winding the wire on going counterclockwise around the pipe. When you’ve reached the bottom, cut the wire at a point where you can push it through the small hole right of the #4 strip, and pull about 4 inches out the end of the pipe. When finished, it should look something like this:

On one end, take one of the completed caps, and push the wire through the small hole you drilled. Alternate pushing the cap in place, then pulling the wire tight. You can give the cap a few gentle taps to be sure it’s firmly seated if you wish. Now, do the same with the other end.

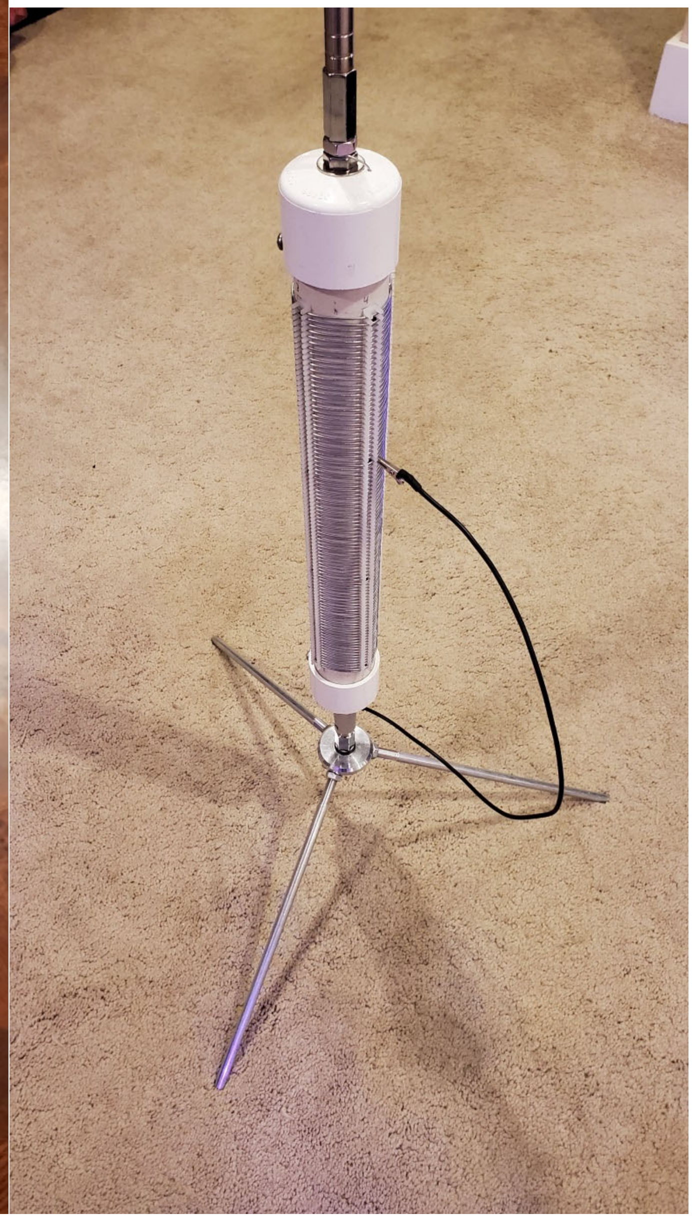
Once the caps on both on and fully seated, opposite where the wire protrudes through the cap, drill a small hole towards the bottom of the cap all the way through the cap and into the pipe. Install one of the small screws on each end and gently snug. This will ensure the caps do not pull off, or rotate.

On one end, take the wire and wrap it clockwise around the bolt so the wire sits on top of the jam nut. Cut the wire so that the end will sit against the threads and not stick out. Thread on a jam nut and tighten. Decide which end you want to be the top of the coil, and add the 3/8”-24 coupling nut to that end.

Prepare the pigtail for the bottom of the coil. On one end of the wire, strip and install the ring terminal. If you want, you can remove the plastic shield and solder it after crimping, then install some heat shrink. Not necessary, but I do prefer the look the heat shrink, and I think it adds a little extra support between the wire and the connector. Install the small alligator clip to the other end and solder. Again, you can use a piece of heat shrink here too, or not. Your coil, your call. ☺ Slide the ring terminal over the bolt on the bottom cap, then install the jam nut.

The knurled piece to the left of the jam nut is a Tram #217 quick disconnect. I use them on all my coils, tripods, and extension pieces. Make it very fast and easy to set up/tear down. This is not necessary, and is not on the parts list. They are available on Amazon if you wish to install a very handy quick disconnect system to your kit.

Here is what your finished coil should look like:

TUNING

Set the coil up in the configuration you plan to operate the most. For this section, I set it up on a Wolf River Coil tripod and attached three 33 foot long radials to the tripod (more on radials later). Coax used was a 50' section of RG8X. Fully extend the whip.

This coil is the 80 through 10 meter coil, so I start by setting my analyzer to the middle of the 80 meter band, around 3.800 MHz. 80 is a big band, and I run FT8 as well (3.573MHz), so I will end up tapping the coil at a few different spots to cover the entire band. From 60 and up however, one tap location will usually suffice.

With the analyzer set to the middle of the band, touch the alligator clip to the last wire, and slowly start dragging it up the coils, touching each wire as you go. At some point, probably within the first 10 or so wires, you will find a spot with the lowest SWR dip. Clip the pigtail to the coil at that spot, and sweep the analyzer up and down. Moving the clip clockwise or counter clockwise around that wire will slightly raise or lower the dip in SWR. To move lower in the band, move the clip to the next wire down. To move up in the band, move it one wire up.

Note the locations where you have the best readings on a note pad, or mark the wires with a Sharpie. But keep in mind, different locations and different Earth under your antenna might affect the resonance points on the coil. At least this way you will be in the ballpark, with only a little touch up needed if anything.

Do the same for the rest of the bands. At some point, depending on the length of whip you are using, you will just be bypassing the coil by clipping the pigtail to the wire on the top cap, and adjusting the length of the whip to tune in each band.

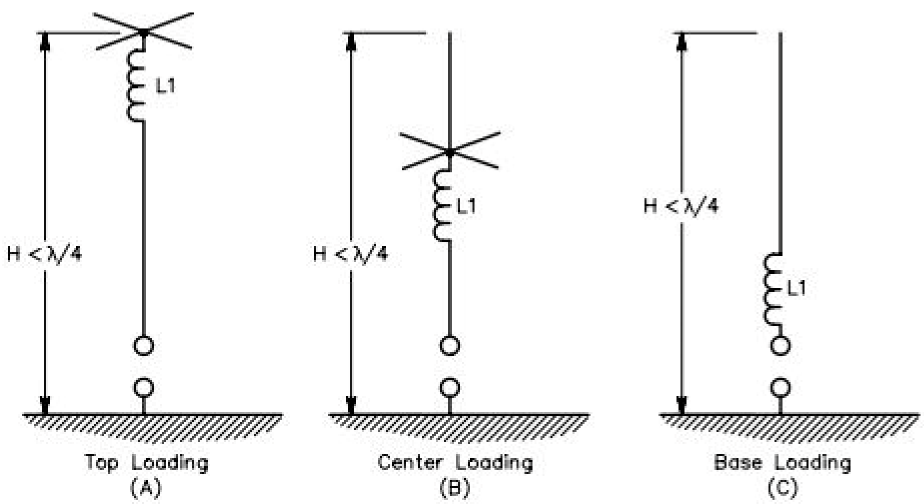
Note that on the 80 meter band, I'm getting a resistance R of about 30-35 Ω. More radials will alleviate that. Note I said more radials….. *more wire on the ground*, not necessarily *longer* radials.

Unless you are elevating the radials, where they would then need to be tuned for length on each band, *more wire on the ground is more important than length*. When I use an antenna system that needs radials, I have bundles of 7 wires that are 11'-12' long each. Tom Schiller (N6BT) found, through extensive real-world testing, that 1/4 wavelength long ground radials are actually ~25-30% too long, which places the maximum current in the ground, rather than in the vertical radiating portion. This usually results in the vertical portion of the antenna getting shortened, ensuring that the maximum current is in the ground. So, shorten the radials instead! Also, this keeps the radial field manageable, my footprint reasonable, and the amount and weight of wire I carry to a minimum.

Now, do you really want to supercharge your portable vertical antenna?

CENTER LOADING VERSUS BOTTOM LOADING

As a lot of us use some form of a loading coil, and some of us center load them. The question usually comes up about what advantage is there to center loading the coil on a ground mounted physically short vertical. After reading through several antenna books on capacitance hats, I ran across this little blurb in an ARRL Handbook:



A group of short vertical radiators is presented in Fig 20.44. Illustrations A and B are for top and center loading. A capacitance hat is shown in each example. The hat should be as large as practical to increase the radiation resistance of the antenna and improve the bandwidth. The wire in the loading coil is chosen for the largest gauge consistent with ease of winding and coil-form size. The larger wire diameters will reduce the resistive (I2R) losses in the system. The coil-form material should have a medium or high dielectric constant. Phenolic or fiberglass tubing is entirely adequate.

A base-loaded vertical is shown at C. ***The primary limitation is that the high current portion of the vertical exists in the coil rather than the driven element.***

With center loading, the portion of the antenna below the coil carries high current*, and in the top loaded version the entire vertical element carries high current.*

<u>*Since the high-current part of the antenna is responsible for most of the radiating,* ***base loading is the least effective of the three methods.***</u>

The goal is the highest possible radiation resistance, which means the longest base length possible under the loading coil of a short antenna. Most losses occur in the loading coil. A large top hat will allow one to reduce the reactance of the loading coil which will reduce losses.

The way it's loaded has little to do with radiation angle; it's all about current flow and minimizing ground loss.

Bottom loaded portable vertical antenna, especially when running high duty cycle digital modes at even moderate power settings, creates a lot of heat in the coil. This creates a source of mechanical failure in the coil itself. The solution is to center load the antenna, move the coil up, thereby moving the high current point up, more evenly distributing it across the system. This greatly reduces losses and <u>HEAT</u>, as well as making the antenna far more efficient.

My solution was to make a copper radiating element to go between the base/tripod, and the loading coil. I made a 3' extension (for the hitch mount) and a 4' extension (for use on the tripod) out of 1/2" copper pipe. I drilled holes in the pipe caps, and after rounding off the points on 3/8"-24 bolts so they would fit into the caps, I generously soldered them into the caps. The caps were then soldered onto the pipe. I installed a plastic guying ring onto the 4' extension. These are MUCH stronger than a piece of soft aluminum round bar, so I expect these to last a good long while.

This setup is without a doubt my favorite antenna to use for POTA. A 4’ extension on the bottom, the 60-10 coil, and a 9.5’ whip on top. I can use this antenna on 60m, 40m, and 30m by tapping the coil. If I tap the coil on the second to the last wire on the top of the coil, I get 20m. For 17m and up, I use the jumper to bypass the coil and simply adjust the length of the whip to be a truly resonant ¼ wavelength vertical.

This antenna takes about 4 minutes to set up. If you want to, you can watch me set it up here:

https://www.youtube.com/watch?v=FfPz7kpJT-w

Well, there ya go! There is nothing new here by any means, just my take on what I wanted in a coil. Since I first built this coil (and others) and make this guide, I have put my coils through plenty of full duty cycle FT8, as well as 100 watts of CW, SSTV, and Winlink email, and it has yet to melt and fall over! Mission accomplished.

Feel free to contact me with any questions at bob@w0bnc.com.

73!
de Bob, W0BNC