HF Helical Whip Calculator

Please note : a new version of the software was made available via this web page on 17 May 2011 to resolve an incorrect result in the calculated maximum wire gauge. If you downloaded it before that date, download it again and replace the original file.

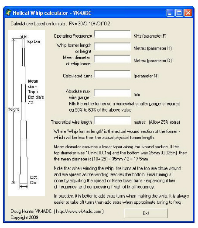
Every so often I find that I need to make up "yet another" HF helical whip antenna - for mobile or portable operation. There aren't too many on-line calculators that will allow you to readily design your own whip to your parameters : frequency, length and effective diameter of the former. I should point out that the calculator software gives you the starting point for creating one - it is not an exact science as all sorts of factors influence the final frequency - how well you have wound it, turns spacing as you get further down the winding.....

One very important thing about helical whips : they are narrow bandwidth devices. A whip for 40 metres (eg 7070) is likely to be only about 20 to 25 KHz wide at the 2:1 SWR points so it is imperative to accurately tune them to the segment of the band you plan to operate - and - do it on the mounting and with the ground plane that you will continue to use it with. On 80 metres, expect around 10 to 15 KHz for 2:1 SWR. In essence they are a physically-shortened radiator and the bandwidth is determined by the physical parameters (eg length) as well as the wire diameter and losses (i.e. Q of the wound inductance).

Way back (1970's or 80s) I bought a multi-page computer printout (about 50-60 pages of number tables) that was used to provide a design for the same parameters used in this application - however it was a reasonably complex process - as against the ease of doing the same today. I guess I was lucky because the front page of that printout contained the formula that was used to generate the many pages of printing - so I eventually used that to create a worksheet in MS Excel. I had been using that worksheet for some years but time marched on so it was time to update and re-do it into a stand-alone Windows application. Accordingly, recently the same formula was implemented in a (pascal-based) Delphi program for Windows 2000, XP & later.

This calculator does not take account of all of the extra effects at RF : it is a simple get-the-project-started device and should be accepted as that.

While the basic software could be used to provide the dimensions for helical whips at VHF and maybe even UHF, that is not its primary purpose.



(mouse over for a larger view)

The program is pretty easy to use : enter the frequency (in KHz) in the top box, the winding length on the former (in Metres) in the next one down and finally the mean (or average) diameter of the former in the 3rd box down (in Metres also). It calculates the number of turns required and then adds some extra helpful info : the absolute maximum wire diameter (in mm) and the theoretical wire length required (in metres). provided there is data in these 3 boxes, you can change the data in any one and it will recalculate automatically. Changing the frequency in the top box from 7070 to 14180 without changing the length or mean diameter will reduce the number of turns, increase the wire gauge and reduce the actual length of wire required.

Example results : 7100 KHz, 1.8 metre long winding section of former, 0.025m (25mm) mean diameter requires 398 turns of a maximum gauge of 0.45mm enamelled wire, a theoretical wire length of 31.22 metres. In practice I would make sure that I have at least 33 to 34 metres of wire available, something around 0.3mm to 0.4mm diameter PEI wire and count the turns as they are wound on. Allow an extra 5% to 10% on the turns count to make up for your close versus spaced winding (eg around 440 versus calculated 400 { and thus needing extra wire }). Terminate the lower end of the wire and start measuring but PLEASE NOTE : Helical whips require a good ground plane - effective at the operating frequency - so must be fed against that "ground" even when testing.

Shifting the frequency from 7100 to 7060 in the calculator (all other parameters remaining the same) changes the calculated turns count from 398 to 400. As you can tell from that, physical construction accuracy is imperative if you have any hope of getting it to resonate at the desired frequency !!!!! (just 2 turns = 40 KHz shift !!)

To download, right click on helicalwhips.zip (/~vk4adc/web/images/UserFiles/File/datafiles/helicalwhips.zip) and select 'Save File As.." from the drop-down menu.
File size is about 200KB and contains one file : helicalwhips.exe, suitable for Windows 2000, XP or later.

(Last Updated 17 May 2011)

Please don't make this calculator software available for download from other web sites as it may be updated from time to time. Simply link back to this page please.

A few things to note :

- When you are winding a helical on a tapered former, (or even a parallel sided one like electrical conduit), you still need to mount it at the bottom somehow. If your piece of "former/pipe" is 2.4 metres long, you might need 300mm for mounting and the bottom terminating point so the actual winding length to put into the calculator is 2.1 Metres. Sometimes it is better to allow for even a shorter percentage of the former as the wound length (e.g. use a dimension of 1.8 to 2.0 metres in the calculator) as this really allows the bottom turns to be spaced out.
- A parallel sided former / blank has a mean diameter the same as its actual diameter. A piece of true 25mm diameter conduit has a "mean diameter of 25mm" so 0.025 is used in the calculator since Metres is the defined measurement base. By the way, for permanent installations, no one says that the former can't be another type of *weather-stabilised material* - like a varnished/painted wooden broom handle ! In some ways, the larger the diameter of the former, the better - less turns but often harder to handle when winding. The software requires the "mean diameter" so if the tube/former you plan to use does NOT have a linear taper on it, you will have to work a little harder to calculate the mean value.

- Always allow extra wire and turns when you wind the whip (I suggest up to 25% more wire). It is easy to remove turns to raise the frequency but adding more is always an issue : dry joints, weak points that break with flexing in the wind....

- Use good quality enamelled copper wire, preferably with PEI insulation. PEI has a higher temperature and voltage rating than PUR even though it has to be scraped to remove the enamel for soldering. PUR insulation is the one that will melt with a soldering iron - easy to tin with a hot soldering iron but lower temperature and voltage rating.

- When I made mine, I used a short length of copper braid slipped over the top end of the whip former, tinned and glued in place, with the top end of the enamelled wire cleaned off and soldered to this tinned sleeve. It helps keep the top in place as you start your winding process and also gives you a simple "snip-able" extra tuning method.

- When you wind a helical whip, the turns at the top of the antenna are close-wound - i.e. the turns are touching each other and pulled tight on the former. Occasionally put a temporary piece of tape around the winding to make sure it doesn't "spring" loose when you release the tension on the winding wire. As you progress down with the winding, the last 1/4 to 1/5 of the antenna are spread out such that the last turn or two might take up even 5 - 10% of the total length. The tuning process is to use an RF impedance analyser (or calibrated GDO) to measure the actual resonant frequency of the antenna and remove turns from the bottom slowly until the resonance has risen to the bottom of the band eg 7000 for the 40 metre band. The final fine tuning is done by spreading or compressing the turns at the bottom to achieve resonance (or a VSWR close to 1:1) at the desired frequency e.g. 7070 KHz. Don't forget to remove the temporary bindings before you heatshrink it.

- Once you have the antenna tuned, place heatshrink over the top third of the whip and shrink it. Measure any frequency shift and re-adjust the bottom turns to correct it. Place heatshrink over the next third (with overlap) and shrink it. Again, measure and correct any frequency shift. Finally shrink the bottom segment (again with overlap) and re-check. Black heatshrink is generally more UV-stable so should last longer out in the weather.

- Originally I used self-amalgamating rubber tape to waterproof a couple of my helicals but in recent times have added a series of tapering heatshrink sleeves over the top of the tape. Do not use normal plastic/electrical tape in the final construction - it won't last.

I have made up helical whips for 3580, 7070, 14170 and 21150 using this method, based on fishing rod blanks, and tuned them right where I wanted them. My oldest whip (7 MHz / 40 metres) is now 20 years old, still gets used occasionally.... and is still tuned to 7070 !

It is a good idea to clearly mark each whip with the band code eg 3.5MHz / 7MHz / 14MHz / 21MHz / 28MHz because one thing I can advise you - they all look very much alike and it is all too easy to screw on the wrong whip for the band you are trying to use !! You can even make one for 27MHz (if you wish) and compete with the commercial antenna suppliers.. and see if yours is better.

Of course these days the whip formers might be the so-called "squid poles", outdoor-rated electrical conduit or even thin-wall fibreglass tube. If you are short on physical space, you can even make up two identical helical whips, mount them horizontally opposite off a suitable hub, and form a rotatable dipole { though this provides only for narrow bandwidth coverage }.

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Update 17 Sep 2009 : Following creation of this web page, I chanced across another web site that also dealt with helical design : http://hamwaves.com/antennas/inductance.html (http://hamwaves.com/antennas/inductance.html)

I put the example values into the calculator on that page, selected turns as 398, used 0.3mm as the wire diameter, left the wire as 'Cu annealed'and it calculated self-resonance at 7.163 (in lieu of 7.100). Adding more turns from my calculator's 398 to 404 brought the frequency down to 7.10046 MHz.

Given that I indicated right in the first paragraph that this calculator is simply a starting point in making your own whips, an error of 4-5 turns in 400 seems reasonable - and mine is a lot simpler to use.

Comparing results also showed up an error in my wire length formula - which has been corrected in the zip/exe file now available for download.