Making your own 2 metre (146 MHz) 5/8th wave whip antenna

March 2010

I went "Googling" recently to find the dimensions for a 5/8th wave whip for 2 metres (146 MHz) and came away disillusioned. I can understand the commercial manufacturers not wanting to publish the physical details but it was strange that I didn't find any articles from amateurs who had built their own. The only info that I did find easily and was remotely relevant was a whip cutting guide at Schultz Electronics (http://www.shultzie.com/downloads/antcharts.htm)' web site.
{ Maybe most amateurs these days are following the black-box mentality and buying EVERYTHING ??? }

That meant that I had to do it on my own - again. My trusty calculator told me that a wavelength in free space is 2.0548 metres at 146 MHz. Therefore the 5/8 wavelength (in free space) is 1.284 metres BUT then you need to apply the correction factor for a physical antenna and my memory recalled that you typically apply a correction factor of 93% to 94% for this style of antenna with an uninsulated radiator. That makes a physical 5/8 wave at 146 MHz a 1194mm length with 93% or 1207mm at 94%. The Schultz site appeared to use a 93.5% (confirmed by back calculation) so I settled for that dimension (1200mm) as a starting point. The table below shows how the vertical radiator length varies with frequency (@ 93.5% coefficient).

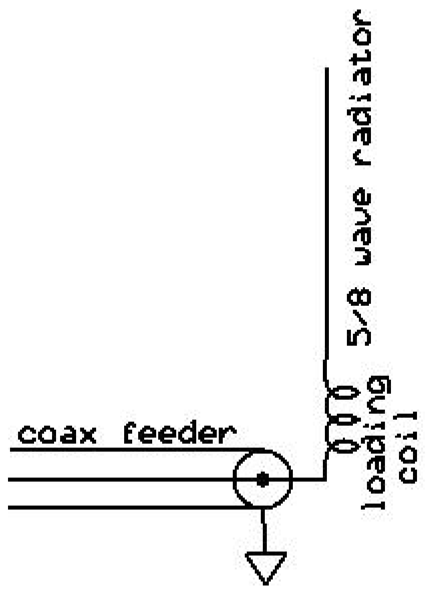
Frequency (MHz)	5/8 wave (mm)	5/8 wave (inches)
140	1252.23	49.30
141	1243.35	48.95
142	1234.60	48.61
143	1225.96	48.27
144	1217.45	47.93
145	1209.05	47.60
146	*1200.77*	*47.27*
147	1192.60	46.95
148	1184.54	46.64
149	1176.59	46.32
150	1168.75	46.01
151	1161.01	45.71

That solved the initial vertical radiator length and told me that the length change to expect per MHz was around 8-9mm.

Just a tip - always start with the vertical radiator a little too long (eg 1300mm for a final 1200mm) because it is relatively easy to cut pieces off but not so easy to add on when you find that it is now too short !!!

I found one of my old (damaged & well worn) commercial 5/8 wave fibreglass high band VHF whips and put a ruler against it to figure out the base loading coil details. It was 11 turns, 40mm long on what I guessed was a 7mm diameter fibreglass section of the whip base. That calculated out to around 135nH (0.135uH) according to my inductance calculator software. My starting point was going to be to try to emulate that inductance because it obviously worked for that manufacturer. I should point out that these fibreglass whips were originally sold with a cutting chart that allowed their use from about 140 MHz to 174 MHz so the base inductance was not going to be super-critical (wavelength-wise) with respect to actual frequency. If I looked through my mounds of old paperwork then I would undoubtedly find one of those cutting charts but this was enough to start with. The purpose of this base inductance is to lower the angle of radiation while making the antenna look like a 3/4 wave whip - thus providing a 3dB gain over a standard 1/4 wave whip (eg so around 5.2dBi) and an overall base feed impedance around 50 to 70 ohms.

I chose a piece of 19mm white PVC tube for my new coil former as that suited my mounting method and then calculated the new coil detail to suit. The results were 5 turns, 19mm diameter, 55mm long to get close to the original 135nH value but with some expansion or compression, the actual inductance would certainly move across the target value.



This base loading inductance is in series with the coax inner connection, with the other end connected to the base of the vertical radiator. The coax feeder's shield is connected only to the antenna's ground-plane. This means that the antenna requires the presence of an effective ground plane at the operating frequency & cannot be operated successfully without one.

Tip2 : Always use the lowest practicable transmitter power into your SWR meter (if testing that way) to preclude damage to the radio from high SWR before the antenna is actually close to finely tuned and the SWR is acceptable.

How you build it is up to you but the two critical details are as listed above, the base coil info and initial vertical radiator length. As you will note above, the only tuning required is the trimming of the vertical radiator to length.

Mouse scroll over the images to see my method in larger detail.

Loading coil assembly after encapsulation with heatshrink. The top thread just visible is 24TPI 5/16" (commonly called "Australian thread" as commonly used on CB and some amateur & land mobile antennas). Inside the bottom metal section is again the same 5/16" thread.

LHS : Magnetic base with 5/16" Australian thread (24TPI) protruding spigot. The moulded base piece (complete with coax cable) unscrews from the magnetised disc assembly for easy packing. The other end of the coax is terminated in a BNC male connector.

RHS : This image also clearly shows the protruding coil termination solder lugs under the encapsulating plastic. The wire used for the loading coil was 14SWG tinned copper.

Base section of 5/8 whip screwed onto the magnetic base.

The top metal rounded conical shaped dome has a 2mm allen screw to retain bottom of the stainless or spring steel whip section. To change the whip arrangement, loosen the 2mm screw and pop in the alternate whip.

The advantage (for me) with this construction is that I have a strong magnetic-base antenna arrangement that I can use with different whip pieces so that I have..
(1) a 1/4 wave whip on 2m (no loading coil and with a 485 mm whip),
(2) a 1/4 wave whip on 70cm (no loading coil and with a 154mm whip), or
(3) a 2m 5/8 whip (loading coil plus 1195mm whip).

The longest physical whip piece is 700mm (the bottom of the two-piece 1195mm radiator) so will fit easily into a suitcase for travelling... and it is all fairly light - an important factor with reducing airline passenger luggage allowance limits.
{ Note : the 1195mm whip is actually cut into two pieces - 700mm + 485mm - and these are joined by an in-line tubular screw-clamp arrangement. }

Unlike many of the cheaper magnetic bases around on the market today, this particular (older) model has real "grip" and it takes a lot to dislodge it off the vehicle.

Why didn't I just buy an antenna & base ???
Simple, I wanted one that I could change the configuration of, was small enough to fit in a suitcase - and didn't cost $100++. (Have you bought or priced a magnetic base lately ???)
I made mine up from parts that I already had - so actual out-of-pocket cost - nothing !

My actual construction method would not suit anyone else so will not be shown here in any detail (photos above excepted) BUT the final test results were interesting.

The spacing of the turns (and hence actual inductance value) of the base loading coil was not particularly critical, no real change in SWR was noted as it was compressed and expanded a bit to change the actual inductance value..
After this test, a large diameter heatshrink was applied over the coil assembly to give mechanical stability and thus a fixed value of inductance.

The vertical whip section was trimmed a little shorter bit-by-bit (around 8-9mm, or 1 MHz, at a time) as the SWR was initially lower at 144 than at 146 MHz (so initially too long - as expected).
The final SWR was 1.2:1 at 146MHz at a radiator length of 1195mm - thus confirming the actual length correction factor was close to 93% for my construction technique.

The final whip assembly also produced a SWR of 1.4:1 at 50.100 MHz - undoubtedly exhibiting a response as a slightly-base-loaded 1/4 wave whip on 6 metres.

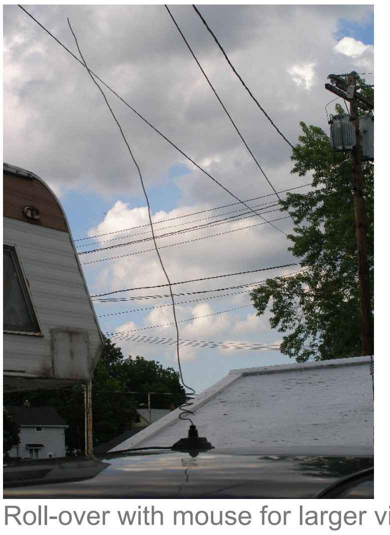
I also tested it at 439.0 MHz (70cm band) and the SWR was about 2.5:1 and, while not great, it would almost be useable if no other antenna was available.
Of course the issue on this band is that the major lobes will undoubtedly be up at quite a high angle and, while suitable for accessing local mountain-top repeaters, would not be particularly suitable for communications at low angles e.g. to contact distant ground stations.

How well did it work ??? Well it is difficult to really do truly quantitative measurements of one antenna against another because factors such as angle of radiation are involved. My best response is : on my normal 1/4 wave whip on a fixed antenna base on the car, one of the distant 2 metre repeaters "showed" one bar on the signal level indicator - and an occasional flicker up to a second - on my Yaesu FT-1802M. Unscrewing the 1/4 wave and screwing on this 5/8ths, done within a couple of minutes - and nothing else changed, either settings or physical environment-wise - the FT-1802M's signal display rose up to around "6 to 7" bars - and the FM signal quieting was certainly better. I don't know what the FT-1802M display change means in terms of actual signal levels in dBm, but using this antenna made an obvious performance improvement. Subsequent time spent driving around through the "same neighbourhoods as previously with the 1/4 wave" revealed better signals from most of the repeaters.

If you are looking to make / build your own two metre 5/8th's whip, at least you found some relevant details - certainly more than I did when I did the same search.

By the way, have you ever heard of a "curly - whip " antenna ????
I used to use one of these on 2m mobile, and another one on 70cm, and it is a similar concept (half wave whip with base loading) except the base coil is wound as a "one turn" inductor with a slight overlap for matching.
I must see if I still have the dimensions somewhere in my filing cabinet .....
Roy VK4ZQ started us using these locally back around the 70's...

Email from a web site visitor :
(29 June 2010)



Roll-over with mouse for larger view

Experimented with your plan for a 5/8 wave 2M antenna today, it worked very well. I used a piece of galvanized wire from my garage, stiff material used to bind things up. I started with a length 60 inches long, made a very crude coil on one end, 3 1/2 turns about 1" diameter, then inserted the end of the coil into a mag mount formerly used as the base of a 1/4 wave 2M antenna. The coil & the whip are one piece. I have an MFJ Antenna Analyzer 259B which basically made my extremely crude efforts pay off. I kept nibbling pieces of wire off the end of the whip until I got an SWR of 1.2-1.6 in the 144-148 MHz range. I did not attempt to stabilize the coil, the SWR varies a bit as the whip waves back & forth, but it is always less than 2.0. The height of the entire assembly from the base of the mag mount to the tip of whip is about 52 inches.

I am able to reach some troublesome 2M repeaters in my area at my transceiver's lowest power settings, settings that do not work with my 1/4 wave antenna. My transceiver's signal strength meter shows several more S-units on signals received from weaker repeaters.

Photo attached. The overhead wires are quite a bit above the top of the antenna.

Not bad for about 1 cent worth of materials, if you don't count scavenged parts and the expense of the antenna analyzer. 73 - Art, KD8CGF

My email response :

Art

Good to hear from you. The main reason that I wrote that page up on my website was that I was building a 2m 5/8ths anyway and I had not been able to find much in the way of technical details on the web as to how to do so. You will have noticed from my other web pages that I now tend to document things so that it can provide an insight for others, particularly with the introduction of the simpler classes of amateur licences (eg our VK Foundation series) and as less-technical people enter the hobby.

It doesn't really matter how the antenna is constructed provided that the bottom coil characteristics approximates mine and that the vertical radiator is around the same length. Galvanised wire probably is not the best material because at VHF the conduction is on the very outside of the wire (skin effect) and I doubt that the galvanising layer has the lowest electrical resistance in the commonly available metals.

Even so, it works for you similarly to what it did for me - and mine was built entirely from bits I had here - i.e. nothing was actually purchased to make mine either.

I might grab your text and photos to add to that web page just to show that the construction details/trends I described do work for others too.

73
Doug

PAGE NOTE : You don't have to have an RF impedance/antenna analyser to tune this antenna. I did my adjustments with a SWR meter that worked to 150MHz, using the lowest possible RF power to give a full-scale forward reference value reading (5 watts) and on a locally-inactive simplex frequency for my testing.

September 2010 :

Incoming email, slight editing applied :

Thanks for the informative subject on this topic.

I would like to construct this type of aerial however my concern is what would be the number of turns required using say no 14 (1.6mm) diameter copper wire wound on a 32mm diameter plexiglas former.

Also would using a larger diameter copper wire alter the number of turns required and performance.

My response :

My L-calculator shows me that for a 32mm OD former, you would need 2 turns spread over about 15mm of coil length to create the required 135nH.. The wire diameter is not overly critical in terms of the inductance but the associated R-losses will be lower with larger diameters. Using 1.6mm diameter wire is fine.

Which in turn raised another point regarding the 5/8th wave antennas :

Doug

Thanks for the early reply.

The ARRL handbook chapter 33-30 shows a diagram for a 2 meter 5/8 wavelength vertical with a 10.5 turns on a 3/4" (19mm) former, with a tap about 4 turns down from the whip end.
Whereas:-

19mm former as in your case for = 5 turns

19mm (3/4") former as in ARRL = 10.5 turns, with a tap 4 turns down from whip end (to centre core of coaxial)

32mm former as calculated by you = 2 turns for my project

Not being in the game of electronics, and pardon me for sounding a bit obtuse, if in adopting the 2 turns does the "bottom" end have to be grounded in some way, or is it just attached to the centre core of the coaxial. If so where is the outer sheath of coaxial attached to.

My response :

There is a major difference in how these two very different construction styles of 5/8th wave antennas are "matched".

The ARRL article uses a tap on the base loading coil to provide a low impedance feed point. The approximate self-resonant frequency of a coil that diameter, number of turns and 25mm long (1") is 147 MHz assuming a stray capacity of 1pF i.e. the basic coil itself is resonant around 147 MHz. The inductive reactance should therefore be about 1080 ohms. The tap at 4/10.5 of the coil should therefore give a feed impedance approximating 156 ohms, so still a low impedance - but not 50 ohms. The half wave or 5/8th wave radiator atop the coil has a high lower-end feed impedance at resonance so the coil /tap provides an approximate impedance match. (I don't have the ARRL book here so I can't look up the original article and am taking your dimensions as gospel)

The 5/8th on my web page uses the "inductor" to do impedance transformation using a different technique so doesn't follow "the rules" as pertaining to the ARRL article. It is more a transmission line-based process. The bottom end of the coil is completely insulated from ground - ie the antenna is open circuit to "ground" if measured with an ohmmeter. In other words, it is just a series inductance that connects to the bottom of the 5/8th wave whip. The inner of the coax feeder goes to this series inductance, the outer sheath goes to the ground plane. (as explained previously further up this page)

My best suggestion is to try making one up quickly (and at minimal cost) following the tips in my article then (1.) measure SWR to see that it truly is under 1.5:1 then (2.) compare gain against a standard 1/4 wave whip screwed in place of the 5/8th on the same antenna base and using the same ground plane (/radials). If it does what I have said it should then make it up "properly".

I hope that provides some additional information about making up 5/8th wave antennas. The loading coil specifics simply aren't. The most critical piece of the antenna is the length of the vertical radiator, not how the coil is made.

3rd Dec 2012 :

G'day,
I stumbled across your site when looking for designs for 5/8 antennas for 2M. I used your design as the basis for an aluminium 5/8 base antenna. I used 20mm o/d pvc pressure pipe for the coil former and 16mm ali tube for the radiating element which ended up being about 1170mm long. I also added four 1/4 gp elements. The result, compared to my 19" whip in the same location were outstanding. I have not finished tuning but at present the SWR varies from 1.5:1 at 144 to 1.7:1 at 148MHz, very broad banded. If you'd like a couple of photos I can email them to you.
Anyway I thought you may like some feedback.

73
Ingmar
VK1BGT
Canberra

Thanks Ingmar. Nice to see that the basic info was of help....

Now for Ingmar's photos :

I've attached a few that show some of the antenna detail. The radiating element is inserted into the PVC for support and the pop rivet and solder tab at the top of the loading coil connect to the bottom of the radiator (as you would expect).

Given Ingmar's "SWR results", the radiator is probably a little too long and is probably resonant below the amateur band. A little trimming is likely to shift it up in frequency and thus provide a lower SWR across the 144 to 148 MHz band.