A Variable Base-Loading-Coil for use under a HF Mobile Whip

29 September 2010

I recently went away for a week's holiday with the camper trailer, taking along the IC-706MK2G (made famous on other pages on this web site) plus the LDG Z100 auto tuner and, to conserve space, just two Mobile One helical whips (http://www.mobileone.com.au/antennas/ham/ham.html), one for 7 MHz , the other for 14 MHz. My operations are primarily "portable", rather than "mobile", so the construction style below is based on that utilisation.

My contemplations were that I would try to track down VK100WIA a few more times to qualify for the WIA's Centenary Award and I hoped to do that on either 40 or 20 metres. In brief, the propagation on 20 metres was poor, 40 metres was good - but no sign of VK100WIA was found.

At one stage with a little free time, I tried to see if the LDG tuner would handle tuning either the 40m or 20m whip such that it would match at 80m - preferably around 3590 KHz. The 40m whip was nowhere near a match. The 20m whip did better but not well enough. I thought of the old ¾ wavelength idea so tried the 40m whip on 15m without real success.

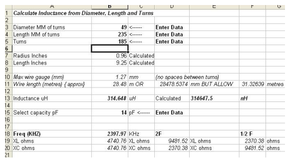
I should mention that one of the effects that I noted was that I could tell where in the 40m or 20m band the basic whip resonated simply by the peak in "band noise" as I tuned the receiver (with internal preamp on) across the band. The 40m whip resonated at around 7085KHz, the 20m around 14180 KHz. The 40m whip also gave a peak around 20910 KHz as a ¾ wave whip but up at 21200 was basically useless. There was no peak on 80m using either whip - but that was expected.

I had plenty of time to contemplate options while I was away. Ideas included an extra top loading coil and short whip extension to add to either the 40m or 20m whip, - or - a base loading coil that could be used for either ??? That does not preclude it's use on a straight steel whip (e.g. a 10m or 27MHz CB style steel whip) but will impact on what bands it would cover.

The ARRL Handbook has a section on base-loading versus centre-loaded mobile whips and the amount of inductance that would be required to tune a standard 2.4m / 8ft whip. I knew I already had a fair distributed inductance in the existing HF helicals but the thought of winding up a large-ish diameter coil to sit above the whip - and mount on a 3.2mm / 1/8" was going to be a mechanical nightmare. I did acknowledge that I was going to have to wind up at least about 160uH of inductance if this idea was going to work for 80m.

I had a look in the workshop and found some white high-pressure PVC tube that would suffice as a coil former. The diameter was 49mm OD, 43mm ID, and there was about 400mm of it available. I have a large roll of 1.25mm enameled wire (around 18SWG) so that would cover the wire requirements.

Out came my trusty inductance calculator spreadsheet - 49mm former, 1.25mm wire.. and set about finding out how much of the tube I would need to wind on to get my minimum of 160uH. This calculator is a good guideline but uses the simple standard empirical formula for inductance of a single layer coil. That turned out to be something well under 250mm (10") when wound with 1.25mm wire closewound but I wanted a little more inductance to give me some flexibility. The calculated details below gave me up around 300uH so it was looking somewhat promising.



	A	B	C	D	E	F	G
1	*Calculate Inductance from Diameter, Length and Turns*						
2							
3	Diameter MM of turns	**49**	<------	**Enter Data**			
4	Length MM of turns	**235**	<------	**Enter Data**			
5	Turns	**185**	<------	**Enter Data**			
6							
7	Radius Inches	0.96	Calculated				
8	Length Inches	9.25	Calculated				
9							
10	*Max wire gauge (mm)*	*1.27*	*mm*	*(no spaces between turns)*			
11	*Wire length (metres) { approx}*	*28.48*	*m OR*	*28478.5374*	*mm BUT ALLOW*	*31.32639*	*metres*
12							
13	Inductance uH	***314.648***	*uH*	Calculated	***314647.5***	***nH***	
14							
15	Select capacity pF	**14**	pF <------	**Enter Data**			
16							
17							
18	**Freq (KHZ)**	**2397.97**	KHz	**2F**		**1/2 F**	
19	XL ohms	*4740.76*	XL ohms	*9481.52*	XL ohms	*2370.38*	ohms
20	XC ohms	*4740.76*	XC ohms	*2370.38*	XC ohms	*9481.52*	ohms
21							

{ Mouse-over to see a larger view }

From the more complex calculator available at http://hamwaves.com/antennas/inductance.html (http://hamwaves.com/antennas/inductance.html), it calculates as a somewhat higher inductance value and the unloaded Q works out at 800 - or higher.

The "getting to be more popular" screwdriver style of HF whip is basically a variable loading coil under a fixed length stainless steel whip - something that Codan here in Australia implemented in their model 9350 auto-tune antenna. These are divided into two distinct types - the motor-driven versus the manually adjusted. This concept is known to work and, while larger mechanically, are much more suitable for the base of the whip**.**

My Mobile One series of HF whips are all the 5/16" 24TPI Australian thread series (though they now make them with a ½" thread too these days - their **AS** series) so that meant I needed to create a device that screwed onto the 5/16" antenna base's protruding metal thread spigot and then have a 5/16" spigot on the top so the existing whip can just screw on. I also had a 5/16" GME knock-down adapter so set about splitting it into 2 (simply by removing the 6mm allen screw) and using those pieces as the top and bottom of this new base loading coil assembly.

How I did the internal mechanical bit is of no importance to this article. Anybody else will have to do it "their way" anyway. The top and bottom photos show how the two segments ended up, everything inside is basically insulator except for the short lengths of wire that go from these top and bottom mountings to the respective solder lugs under the protruding screws.

The inductance results : I managed to wind the coil by hand in about 20 minutes then terminated the finishing end on the relevant solder lug and put my inductance meter on the total coil : 320uH (though how accurately it measures relatively small inductances is an unknown, but certainly it agrees in general terms with the Excel-based calculator). That was certainly double what I thought I would need so I considered that part a success. The final coil turn count was not made but an estimate of 180 was calculated based on actual coil length (235mm).

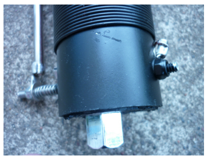
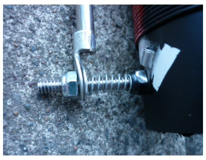
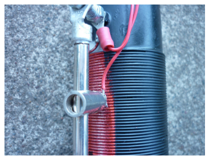
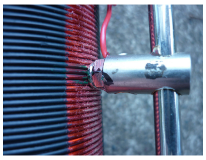
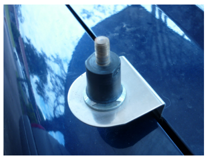
To finish the coil structure off, I used a strip of insulation tape along the line that the contacts would move, the screws at each end etc... and sprayed the coil assembly with a flat black enamel paint - several heavy coats. This is to (1) protect the insulation on the enameled wire, (2) provide a stabilizing "glue" effect on the turns and (3) make the device a little less noticeable physically (a white tube with gleaming enameled wire really stands out !).

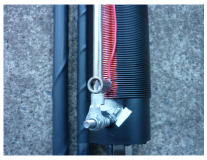
Now for the variable contact part. This is actually a plated steel rod soldered to two large solder lugs with a spacing to fit the screw separation. Along it slides a 10mm plated brass tube about 25mm long which, in turn, has a 3/16" whitworth nut soldered to the end. A short dome-head was then inserted into the nut and it is the "contact" with the turns on the coil. The photo shows the construction better than I can describe it. Note that I don't really trust the electrical conductivity of the slider arrangement so it is shunted by a flexible wire right back to the top of the coil.

The solder lugs on the main rod are fitted on the screw threads after a compression spring and flat washer, then the rod/lugs and finally a Nyloc nut. The nuts are adjusted so that with the slider at either end of the rod, the relevant nut is tightened to compress the spring and provide a good, but not heavy, physical contact with the coil turns. The slider contact should be able to be slid along the rod and make electrical contact throughout.

The outcome :

{ Mouse-over images to see a larger view }

 (/~vk4adc/web/images/UserFiles/Image/baseloading/P1030858.jpg) This is the bottom of the base loading coil. The inset thread is 5/16" 24TPI "Australian" thread. The end "filler" was made with a piece of "chopping" board cut to shape.	 Slightly more side-view of the base, this one showing the bottom end of the slider rod plus the screw termination for the "bottom" of the coil on the opposite side of the tube.	 Top end of the tube. Note the protruding 5/16" threaded spigot. The normal HF helical simply screws onto this spigot. This end filler was also quickly made from another piece of "chopping" board. It doesn't really need to be weatherproof because inside is basically all insulating material.
 Closer view of the bottom of the slider rod. The spring is compressed by the Nyloc nut as per the adjustment procedure noted above. The solder lugs on the end of the slider rod were intentionally positioned this way around for maximum physical strength.	 Top view of the rod. The extra Nyloc nut holds the solder lug for the flexible shorting strap so the top spring has far more compression.	 The enamelled finish was lightly burnished off the wire along the track under the slider rod to allow for good electrical contact.
 Close-up of the slider contact. The 10mm plated brass tube with the 3/16" nut soldered to the end and a short 3/16" whitworth screw as the actual domed contact. The mark just to the left of the contact is the tuning point for 160m while using the 20m whip.	 The car I did my testing on just used what we call a "Z-mount" with a SO239 base plus a Mobile One PL259 to 5/16" adapter fitted to it.	 This is the view with the base loading coil screwed onto the base in the previous photo.
 This is the bottom of the 2 helical whips, a M40-1 and an M20-1 for 40 and 20 metres respectively	 This view shows the inset 5/16" thread on the bottom of the whips	 The helical whip simply screws onto the top of the in-line loading coil.

 A slightly different view showing the completed assembly.	 This shows the wire fully extended when the slider is at the bottom of the coil.	 Second view with the sliding contact virtually at the bottom of the coil so minimum introduced inductance.
 The second vehicle has a heavy duty base mounted off the inside of the "nudge" bar - but there is insufficient clearance to just screw the base loading coil onto the base itself.	 Fortunately I stll had a couple of 5/16" spring bases and they provide just enough height to avoid the horizontal section of the "nudge" bar.	Although I haven't done so as yet, I could connect the lugs on the opposite sides of the bottom of the coil former with a short double-ended shorting strap (eg with crocodile clips) and thus eliminate basically all of the coil's inductance and leave only the vertical rod's contribution.

You will note some marks along the enameled wire and these are as a result of my testing it with the same two whips I took away with me, for 40m and 20m.

First I added the 40m whip, slider right at the bottom (so minimum inductance), set the IC-706 to 7100 KHz and pressed the Tune button. The LDG tuner "buzzed" a short time then the green LED flashed 3 times to indicate the SWR was under 1.5:1. Lots of band noise in the receiver too.

Next was 3590 KHz. I adjusted the slider contact for maximum band noise, about 1/3 of the way up the coil, pressed the Tune button, some "buzzing" then again the green LED flashed at me.

Hey I was only using 1/3 of the coil !! Next 1825 KHz. Again contact slid along for maximum band noise - about 80% of the coil now in circuit. Tune button, "buzzes", green LED again. Hey I was impressed. My original idea was to get access to the 80m band and here I was getting 160m tuning too.

Time to try again with the 20m whip only this time try it on 40m too.

On 7100 KHz, slider peaked around 10% of the coil, green LED.

On 3590 KHz, slider peaked around 50% of the coil, green LED.

On 1825 KHz, slider peaked just over 90% of the coil, green LED.

Hot diggety - either mobile whip would give access to the 40, 80 and 160m bands..... with the added bonus of the 20m whip would give me 20, 40, 80 & 160 in one antenna ! Maybe my whip antenna collection being taken away on trips might yet get smaller.

Operational note : You need to put your tuner into "bypass mode" when actually trying to **initially peak the sliding** contact point on the coil for any band for any specific antenna - at least until you know where it belongs e.g. by returning it to a previous marking. Because a part of the coil is always "shorted" by the connection arrangement, and the contact will typically touch 2 or 3 turns at a time, there is some latitude in physical re-positioning.

What did it cost me - a 5/16" knock-down adapter (about $30), some "50mm" high pressure PVC pipe, a few 3/16" screws, nuts, washers, 2 compression springs, some solder lugs, a bit of plated steel rod from the 'junkbox', some enameled wire, an old kitchen chopping board and some imagination.

Total build time from start to finish - about 5 to 6 hours, and that included deciding how to build it, finding the bits I needed (not an easy task at my place), winding the coil, waiting for paint to dry, a lunch break, making the slider mechanism and testing the coil in conjunction with the two whips !

Not a bad effort for a half a day......

One thing I have not brought up before is that the efficiency of "loaded" HF mobile antennas is **always** poor - and it does not matter whether it is a base or centre loaded whip, a helical or straight metal construction. Anything that is physically small with respect to wavelength always is. The mobile whip also has the disadvantage of a small "ground plane" area so most of the transmitter power is lost in resistive "components" rather than actually radiated.

My personal preference is for a separate helical whip for each band but that becomes a physical nightmare if you want to change bands "on the drive". You do have to stop and change whips over. Of course you are in the passenger seat while you are intently operating your radio - aren't you ???

In real terms, I seldom operate HF while actually "mobile". My operations are really "portable" while parked in a campground, maybe some remote site on a amateur radio field day. The construction described above is not really strong enough to support a large whip whilst driving though maybe you can use my ideas to make something super-strong.