The Full Wave horizontal Loop antenna – Ed VK2JI (v6)

Following on from my article on the ground antenna in the last edition of Smoke signals, here's another “different” antenna. Another one that is supposed to perform really well – let's see how this one does!

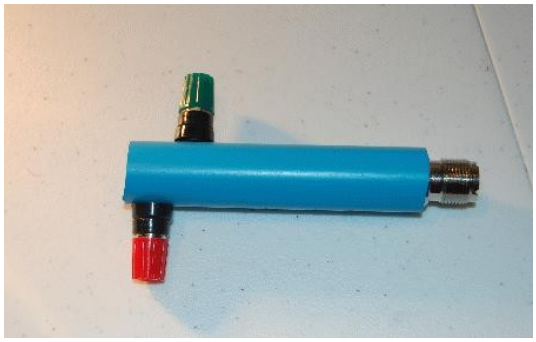
My interest was aroused by an article from Ray Howes, G4OWY in the October 2012 AR magazine entitled 80m or 40m to 10m – just one loop fits all.

He goes on to describe a full wavelength horizontal loop antenna that he suspends from two trees and two points on the back of his house. The big disadvantage of this antenna is it's physical size – especially if you build the 80m or 160m versions. I could just squeeze in the 40m version with it's roughly 11m metre sides, but not if I allowed for the support ropes in Ray's design, so mine is a revised version of the design with no insulating ropes or egg insulators. As my intent was to use this as a portable antenna, the lower the number of the parts the better. Of course being portable, you can chose a location with trees – whether you'd find a site with trees nicely about 11 metres apart in a square however is another matter!

So I'd like to install and test in my small garden and have a solution that I can take out and set up easily portable. The answer … an Aussie favourite – telescopic squid poles. So I ordered 4 x 5m heavy duty Squid poles and 4 metal post bases for them. I chose the 5m rather than 6,7 or 9m ones simply on price (the 9m ones also wont fit the base poles). If this all doesn't work I don't want to have wasted too much money. If you want to make this aerial at an even lower cost bamboo poles can be used in place of the squid poles but they would be less suitable for a portable configuration. (Thanks to Graham, VK2GRA for this suggestion).
The posts will fit into the corners of my garden and the squid poles go into them. Being fibreglass these posts don't have an impact on the antenna, so why use insulators? The wire is simply wound a couple of times around the rubber caps on the top of the squid poles and taped there with electrical tape to stop it slipping down as the pole is raised.

Now what about the antenna wire? Yes with such a large antenna you need a long lengths of wire – about 43-45m for the 40m version. Ideally it should be copper wire (yeah sure! Have you seen the price of copper?). Looking for a cheap option, I looked on eBay and found what I thought would do – flexible garden wire in a 50m roll. $12. Not $12 for one roll, $12 for 15 roles! Oh well it's cheaper buying these 15 rolls from here than one roll elsewhere and I can also give these away to others wishing to build the antenna.

So what else do we need – ah yes, some way to connect the co-ax to the garden wire that is light but stable. The co-ax outer goes to one end of the wire, the inner to the other end. Well I considered a piece of plastic kitchen board but when the squid poles arrived they came with some blue plastic tubing that had been used simply as packaging material. I cut a small piece off one of these, bought some screw terminals from Jaycar grabbed a short piece of 50 ohm coax and a SO-239 line socket and all was set (see pictures below).

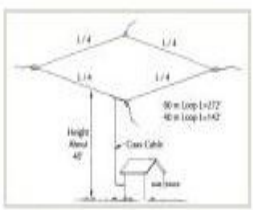


I was rather proud of this solution. It is strong and looks tidy (the screw terminals are offset other wise they would short inside the unit).

So now it's time to test, all the parts have arrived, I had booked out the clubs antenna analyser so everything was ready. Initially I thought I'd just check how stable the squid poles were in their mounts (I don't guy these as the antenna wire holds them together). They were fine once I added some rubber bands to close the open side of the top of the holding poles. As it was still light I decided to start and put up the antenna. The biggest problem was the garden wire twisting and kinking so that I couldn't get a straight run out but after about an hour all was unwound attached to the squid poles – the SO239 unit attached between the wire with the length longer that I expected I'd need (but not yet cut), and the coax was connected to the antenna analyser and everything was ready to go.

My first tests on the antenna showed it was at resonance at about 6.6MHz - no worries drop the one pole down, shorten the wire and test again. This time it was 6.8MHz, OK I can take a lot more off …. Next attempt still 6.8MHz – No wait …. 8.6MHz ! I cut it too short. Oh well while this is a test (and I have plenty of spare wire once I get it right), I attached part of the wire that I had cut off and tested again and after a couple more attempts, I get the antenna nicely resonant across the 40m band.

By this time it's getting dark and cold, so I disassembled everything and headed inside. One disappointment was although there was a dip at resonance it was only dipping the SWR bridge down to 3:1. While wondering what I need to do about this, upon reading the G4OWY article again, I see that he said the best he could get was 3.1:1 so I hadn't done anything wrong, this antenna seems to need an ATU because of the bad SWR.



The loop is erected horizontal to the earth

I wasn't happy with this however, so I went looking on the Internet to see if the antenna might give a better SWR with a Balun or some other solution. Which is when I came across the article
"Full Wave Loop Antenna" by WH2T.
Reading this article I again heard how much better the loop is to a dipole or a vertical with 2.1 dbd of gain, a lower noise level and broader bandwidth. So my enthusiasm came back, but what about that 3:1 SWR?

Reading further in the article (which covers loops up to 160m and how to calculate the size for any frequency) I found that the author had found a way to address the SWR by using a “Q section” simply introducing a 75 ohm length of co-ax before your normal 50 ohm feed. The loop has a nominal impedance of 100 ohms – no wonder I was getting a 3:1 SWR. The length of the Q section depends upon the frequency the loop is being built for and the velocity factor of the coax you use. Formulas to calculate the required length of the loop and this Q section are at the end of this article.

Transmedia KH21-100DP Coaxial Cable KH21 Quick Box 100m

TV / SAT, Coaxial - 75 Ohm (Class A) 100 m, white, quick box

- inner conductor ø mm, material 1,1 Cu
- insulation ø mm, material 4,8 foamed PE
- 1. screening, foil Al-foil double faced
- 2. screening braid, material 128 x 0,12 Al
- jacked ø mm, material/colour 6,8 PVC/white
- attenuation at (20 °C in dB/100m): 100 MHz 5,1 dB 200 MHz 6,9 dB 300 MHz 8,8 dB 500 MHz 12,2 dB 800 MHz 15,6 dB 1000 MHz 17,8 dB 1350 MHz 21,7 dB 1750 MHz 24,4 dB
- 2050 MHz 27,8 dB
- impedance 75 Ω
- screening immunity > 95 dB
- velocity factor v/c 0,80
- min. bending radius mm 35
- coil packing 100 m
- printing on cable jacket: DOPPELT GESCHIRMT FÜR DIGITALE UND SAT-ANLAGEN
- ZZF G 686 561 B CE digital "meter print 100 m -> 1 m" Class A

I took a look in my shed for some 75 ohm coax and came back with some meant for satellite dish connection. I managed to find data about this cable on the Internet and the important information – its velocity factor – which is 0.8.

Upon calculating the length needed, I could not believe it but the length I had was exactly what is needed!

So now it was time to disassemble the connection device that I was so proud of and connect the far longer section of 75 ohm coax in it and have the SO239 hanging loose on the end of the co-ax.

The picture to the left shows the new unit.

On my next test - Success – or at least marginally better with the length of 75 Ohm co-ax than without – I now have an SWR of between 2 and 2.1:1 at resonance. I had also replaced the antenna wire with one of the other 50m rolls of garden wire and cut the length exactly using the antenna analyser.

This was a “quick” Friday lunchtime test, but I still had chance to bring the FT-757 out to the deck and connected it up to see what I could hear and work on 40m – one of the worst days for propagation on 40m during the day for some time. All I heard was a VK3 complaining that conditions were terrible! Well I checked transmit as well with up to 100W and the garden wire took it OK, with that 2:1 SWR. Next test will be at the weekend when hopefully conditions will be better, a few more people are around and I can run a direct comparison between the loop and my trapped wire dipole.

Well, the weekend came and my chance to perform a real comparison over my other antennas of the “DX-Buster” 40m full wave horizontal loop.

Everything went back up – the squid poles, the garden wire, the Q-Section 75ohm coax etc. In fact this time I moved two of the squid pole bases out a little to try to get rid of the slack in the wire to try to get each leg horizontal. I got it better but not yet perfect.

I ran a length of coax back to the shack and checked SWR – horrible! I traced the fault to the SO239 line socket on the end of the 75 ohm lead and did a temporary fix (later remaking the connection properly).

I tuned around on 40m and immediately it was obvious I got a lot less background noise than on either my SRC X-80 vertical or my Rippletech trapped wire dipole antennas. The signals may have been a little stronger as well but the main thing was with the lower noise level, they were a lot, lot easier to listen to.

So how about a transmission test. SWR now is good, just under 2:1. I interrupted John VK2FJKH and Pete VK2FMSL on the 2m repeater and asked if they could possibly QSY to 40m and see what kind of a signal I was putting out and they kindly agreed to do so.
After putting out a call there, not only did John & Pete come back but also Arthur VK2FHAY, Dave VK2FEAA and Pat VK2AAE. All of whom, I could here far better than ever before. Even Pat with his antenna laid on the ground and down at S2-3 was fully readable because of the lower noise floor.

This was a very successful test and I could conclude that the Loop in the back garden was better than either of my other two antennas, perhaps because it was further away from the in-house electrical noises but I think it is more than that. It also is the first HF antenna that I have found that allows local communications.

I then decided to try the antenna on other bands, I knew 20m was resonant, I had seen that previously on the antenna analyser, but would 10m also be? What about the WARC bands – they shouldn't be resonant, should they? Just using the built-in ATU in the TS-2000 to tune the antenna, it worked well on 20m, 10m and 15m. It even seems to work fine on 12, 17 and 30m although all I could find there was digital & RTTY signals and a bit of CW (well this was mid-afternoon still) – but it WORKED with an SWR under 2:1 on all of those bands! I could even hear the test Morse transmissions on 3.7MHz – and this antenna shouldn't work on 80m, it's a 40m loop. Although the SWR on 80m was OK 2.5:1 it really does not perform well there, that would need the 80m version. The antenna would not tune with the ATU on Top Band (160m) – I would have been extremely surprised had it worked there!

So what now? Now that it is clear that the antenna does indeed work, I'll look at moving up from the 5m squid poles to the 7m ones, the extra height should bring extra gain. I also need to move the bases out a little more to make the wire actually horizontal all the way around the square “loop”.

One thing is for sure, this antenna works very well for such a simple antenna. It's an antenna that anyone can build. Having the antenna analyser on hand to set the correct garden wire length is the only technical issue however that's an advantage of being a member of the CCARC club, we have one that is loaned out to members.

There is no reason I can see that 80m, 160m and 20m versions of this antenna should not work as well as this version. Of course for the 80 & 160m versions you need a lot more space – perhaps keep those options for when operating portable? Perhaps make 40,80 & 160m wire lengths and keep them available to put up whichever version of the antenna is needed when out portable, i.e. one set of poles with three different antenna options?

Improvements to the basic design:

While the article above describes a working solution, the action of running out the 40m plus length of wire each time I wish to raise the antenna becomes a pain as the garden wire ties itself in knots. I wondered if I could rig some way of having the wire for each side of the square as separate lengths, so making setting up and taking down much easier.

I decided that using more of the screw terminals on the plastic tubing at each squid pole would be a practical option, so I made up three more tubes each with a terminal, cut new lengths of garden wire each ¼ the length of the first antenna wire. Put everything up and guess what … the antenna was no longer resonant on 40m, it was down around 6.6MHz, so with the help again of the club's antenna analyser, I trimmed back each wire in turn and after taking between 4 and 5 inches off each of the "elements", we're back resonant on 40m and 20m. Testing again showed a great signal to noise ratio when compared to the dipole.

In all tests up until now, I have simply taped the coax connection point plastic tube (and now the "element" connectors) to the top of each squid pole. This is fine for a temporary set-up but the tape dries up and they simply don't look good. So I have now filed down the rubber balls on the top of the squid poles, so that they can go inside the plastic tubes (stopping going through when they hit the screw at the back of the screw terminal). In the case of the co-ax connection point this meant I had to move the coax so that it came out of the top of the tube instead of the bottom.




So now I have an easier to assemble but still as good performing 40m full wavelength horizontal loop antenna that I can put up in about 20 minutes and take down in 15.

I have also now upgraded from the 5m to the 7m Squid Poles which delivered a further improvement to remote signals working 5-9 into West Africa and down to Campbell Island.

It appears getting the antennas up about 20 feet above ground allows to operate free of other objects that may de-tune it.

FORMULAS:

Loop:

To determine the approximate length in feet of a Full Wave Loop antenna use the formula

1005/frequency in Mhz = length in feet or

306.5/frequency in MHz = length in metres.

For 160 metres a full wave loop antenna resonant at 1.9 MHz would be 529 feet or 161m long
For 80 metres a full wave loop antenna resonant at 3.75 MHz would be 268 feet or 81.7m long
For 40 metres a full wave loop antenna resonant at 7.1 MHz would be 141.5 feet or 43.2m long

Always start with a slightly longer length so that you can prune the wire to obtain the best VSWR.

Q-Section.

The Q_section is used to match the ~ 100Ohm impedance of the loop down to the 50 Ohm impedance of the feeder to your rig.
Connect the shield of the 75 ohm coax to one end of the loop and the centre of the 75 ohm coax to the other end of the loop antenna. The length of the 75 ohm coax “Q Section” is important to match the antenna at its primary resonant frequency.

To determine the length to use, Use this formula

"Length in feet = 246 x VF / frequency in Mhz" or

“Length in Metres = 75 xVF / frequency in MHz”.

VF = the Velocity Factor of the coax.

So multiply 246 (if working in ft) or 75 (if working in metres) by the Velocity Factor of the coax, then divide by the primary resonant frequency of the loop antenna.

Cable Velocity Factor and Loss Data (per 100 feet)

TYPE	VF	LOSS @ 10 MHz	LOSS @ 50 MHz	LOSS @ 100 MHz	LOSS @ 400 MHz	LOSS @ 700 MHz
RG-6/U PE (Belden 8215)	66.0	0.8	1.9	2.7	5.9	8.1
RG-6/U Foam (Belden 9290)	81.0	0.7	1.7	2.5	5.3	7.2
RG-8/U (PE (Belden 8237)	66.0	0.6	1.3	1.9	4.2	5.9
RG-8/U Foam (Belden 8214)	78.0	0.5	1.2	1.7	3.9	5.6
RG-8/U (Belden 9913)	84.0	0.5	1.0	1.4	3.4	5.0
RG-8X (Belden 9258)	82.0	0.9	2.1	3.1	6.6	9.1
RG-11/U Foam HDPE (Beld. 9292)	84.0	0.5	0.9	1.3	2.3	3.3
RG-58/U PE (Belden 9201)	66.0	1.1	2.5	3.8	8.4	11.7
RG-58A/U Foam (Belden 8219)	73.0	1.3	3.1	4.5	10.0	14.2
RG-59A/U PE (Belden 8241)	66.0	1.1	2.4	3.4	7.0	9.7
RG-59A/U Foam (Belden 8241F)	78.0	0.9	2.1	3.0	6.6	8.9
RG-174 PE (Belden 8216)	66.0	3.3	5.8	8.4	19	27
RG-174 Foam (Belden 7805R)	73.5		4.6		14.0 (450)	20.9 (900)
RG-213/U (Belden 8267)	66.0	0.6	1.3	1.9	4.1	6.5
LMR-240	84.0	0.8	1.7	2.5	5.0	6.6
LMR-240UF	84.0	0.9	2.1	2.9	6.0	8.0
LMR-400	85.0	0.4	0.9	1.2	2.5	3.4
LMR-400UF	85.0	0.5	1.0	1.5	3.0	4.1
Davis BuryFlex	82.0	0.5	1.1	1.5	2.9	3.8

If you use RG59 or RG11 with a Velocity Factor of 0.66 , For the 80 metre band the piece of 75 ohm coax should be about 43 feet (13.2m) long. RG59 and RG11 coax usually have a Velocity Factor of 0.66 , Foam dielectric coax such as RG6 might have a Velocity Factor of 0.81 or more.

Put an SO-239 line socket on the unused end of the 75 ohm coax, (alternatively if you don't have an SO239 line socket you can use a PL-259 and screw a PL258 double female coax connector onto this PL259 coax connector). Then connect any length 50 ohm coax needed to reach your transceiver.

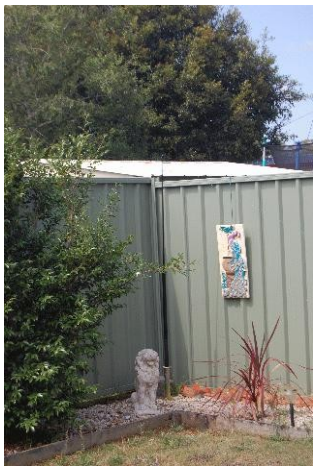
Pictures of the antenna installation;

Initial set-up at ground level.

Up in the air (coax feed point).

In the air but barely visible.

Simple base mounts hold the squid poles (without any guy ropes).



S2 fully copyable signal with no noise level.

Usage update #1 16/12/2012:

While this was envisaged to be a portable antenna, to be put up and taken down in various locations, the fact that it performed so well in my tests means that it has been left in position and continued to perform well until today when the SWR went bad. Upon inspecting each of the terminals where I connect the 4 lengths of garden wire, I found rust on both the wire and the terminals. My plan is now to tin the wire ends to protect them and then to wrap the terminals with coax (amalgamating rubber) tape to protect them from the weather.

Usage update #2 22/4/2013:

I am glad to report that this antenna continues to amaze me with a good performance and the ability to work distant stations and those close by as well. The first HF wire antenna that I have found that can do this.

I recently decided to give the antenna and upgrade replacing the single core steel garden wire with some wire meant for use on antennas – I bought 50m of tinned copper wire from NBS antennas. A very nice wire, rubber covered and very hard to make tangle. It was of course a little heavier than the current wire and I deployed it with extra length, so that I could trim to resonance. The result was a far from a "horizontal" antenna with the sides between the squid poles drooping and the poles pulling in a little. In any case, I thought, once I tune this I will definitely have to shorten the sides, so let's see how it looks then.
Putting my antenna analyser on the aerial showed it was already on resonance - with SWR figures at resonance about 0.3 better than with the old wire.

So what have I learnt - if you increase the diameter of the wire by going from single core to 30 strands, the length of wire required to get to resonance increases.

As my squid poles are already at the corners of my garden and the droopy wire, simply looked awful, it was down with the new wire (I'll use those lengths with my portable loop antenna) and back up with the cheap garden wire which as well as being lighter is also less obvious to the neighbours.

As I told myself having used a good three hours on all of this work "experimentation and discovery is part of the hobby" - I'm still amazed at the antenna, even with it's "cheap wire" - perhaps more so because of it !