helix.air.net.au

Preface

This is a sligh rehash of the original article from 1999. It's still useful as a guide though some of the sh
exist any more and if you look around the WWW you will find variations of this design.

Introduction

As some of the readers may know, an effort by members of the Canberra Linux Users Group h
to set up a Canberra-wide wireless LAN. This amateur experiment's existence is largely due t
many cut-price old style Lucent WaveLAN cards being superseded by the IEEE 802.11 standa
cards were cheap but the tile antennas that came with them are no good for long haul links of
hundred metres. On top of this, commercial aerials that can do the job are expensive, can get
are ugly, especially the conifers. My Mum would not want one on her roof.

Consequently, there is no reason why this aerial couldn't also be used with any other equipme
broad bandwidth in the 2.425GHz band such as the new 802.11 wireless network cards or vid
anyone does use the aerial with these bits of equipment, please let me know!

The idea behind this aerial was for anyone to be able to make their own aerial for point to poin
cheaply. The criteria are cost effectiveness, ease of construction and durability. Durability is i
don't want wind, beak cleaning magpies and highly destructive nibbling cockatoos ruining you
Unreal Tournament sessions. Birds landing on the aerial have the effect of severely diminishi

The aerial was derived from information on helical antennas in the ARRL Antenna book.

Any places and shops referenced are in Canberra, Australia.

Parts

To construct ***one*** aerial you will need:

- 1 x 0.55 metre length of 40mm PVC plumbing pipe (40mm inner, about 42-43mm outer diameter
- 1 x 40mm PVC endcaps
- 1 x 150mm PVC endcaps OR a sturdy thick piece of plastic or wood of similar dimensions
- 2 x 25mm or 35mm U-bolts
- 8 x extra nuts for U-bolts
- 8 x extra washers for U-bolts

- 1 x 5/16" round head bolt (must be short kind) and nut and washer to suit
- 1 x sheet of 0.4 - 0.7mm thick brass shim (sheeting) large enough to cut a 130mm diameter circle piece of aluminium from a Sara Lee (or like) apple pie tin. Plain old aluminium foil is too thin ar drill and cut it..
- Several metres of 1mm enamelled copper wire (can be greater but not much smaller than 1mm)
- 1 x panel mount N-connector (the kind with a square base and 4 screw holes, Dick Smith has ther
- 3 x screws, nuts and washers to suit N-connector
- Printouts of the PDF files below
- Slow drying Araldite
- Loctite 424 or similar (superglue could do or a hotglue gun would do)
- sealing silicone
- masking tape

Tools needed are:

- Hacksaw
- Big flat file
- Big strong wire cutters
- Spanner to suit 5/16" nuts
- Philips screwdriver for the N-connector screws
- Drill
- Plethora of drill bits from small to really big
- Soldering iron
- Scissors (but not the Good Scissors, because you will wreck those and your Mum will kill you.)
- Stanley knife or scalpel

The endcaps must have a completely flat base. Hardware House and BBC have these as do Warehouse in Fyshwick (next to Dick Smith) where I got mine. Canberra Southern Plumbing I dimples in the centre right where they would obstruct the placement of a bolt.

You can get the U-bolts and nuts and washers from Hardware House or BBC.

The brass shim is available in whatever length you need from Belconnen Metal Centre. They stuff rolled up. Tuggeranong Metal Centre should have it too.

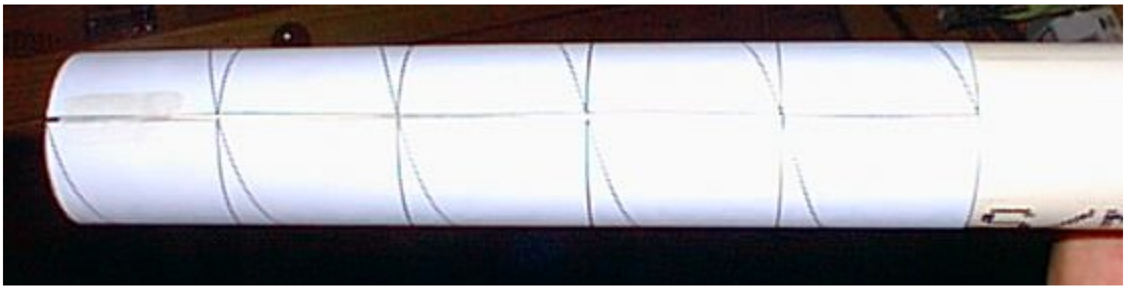
Construction

- Print and cut out the templates in the PDF template file.
  - circle.pdf (the backplane)
  - rhspiral.pdf or (wire winding templates)
  - lhspiral.pdf

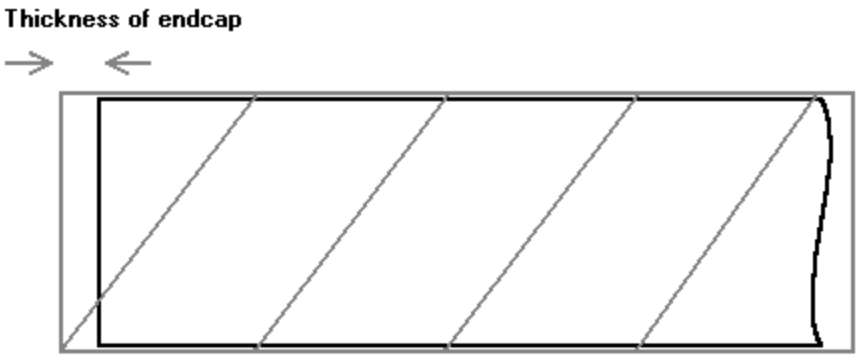
- Use rhspiral for right handed spiral helicals and lhspiral for left handed spirals. You will need the ground plane (reflector), unless you can prescribe a good 130mm diameter circle yourself with a ı circumference.

- Cut a length of 40mm PVC to 550mm (55cm).

- Wrap the winding template around the PVC tube and tape the seam together. It doesn't matter if y or LEFT handed template so long as the helical at the other end is the same. Make sure the spiral seam. A small gap at the seam is OK. *If you combine a left handed aerial with a right handed ae* *virtually no usable signal.*



- The end you start the template at will be the end that connects to the base. Note, you should start protruding about the thickness of the endcap over the edge. See diagram below. This will compe thickness of the 40mm endcap



- Using a sharp point like a scribe, perforate the template along the helical line at regular intervals, revolution. This will leave marks in the PVC you can follow when wrapping the wire around. Sl along in stages until you gave a complete spiral running the length of the tube. Mark the where th on the template finishes. You should have a few mm of tube left over. This is OK.

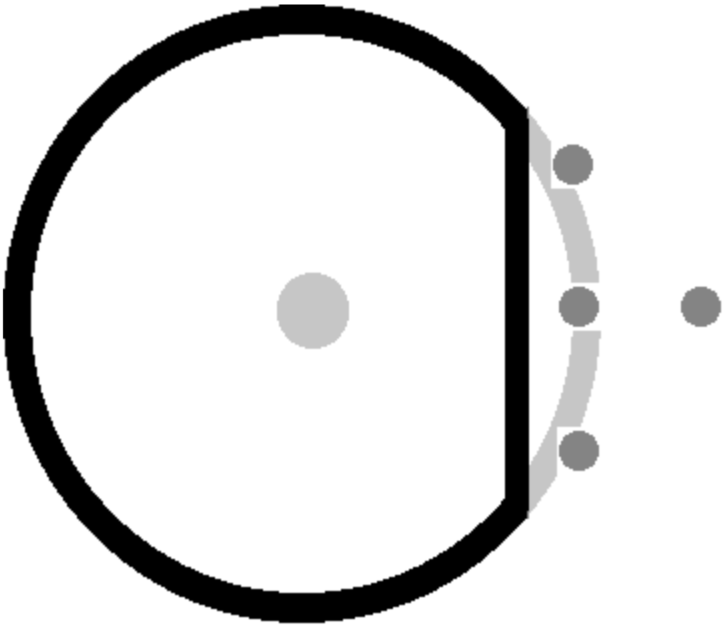
- Take the 1mm wire spool and using something like superglue or Loctite 424 attach the end of the spiral ends at the tube (the end point described above.). Slowly wind the wire around the tube, fo indentations. At fairly regular intervals like a 1/2 or 1/3 turn add some more glue to hold the wire

- As you approach the base end don't glue down the last turn and leave plenty of excess wire (10cm the end. Let the glue dry.

- Cut out from the brass shim or Sara Lee pie tin the 130mm diameter circle (from circle.pdf).

- Drill holes in the 150mm endcap and 130mm sheet to allow for the centre bolt and N connector h I marked the positions of everything by centreing the base of the 40mm endcap onto the base of th and drawing the circumference as you can see below. I then positioned the N connector over the it needed to fit, seeing as the N connector stub has to be right on the outer edge of the 40mm tube

- Take the 40mm PVC endcap and cut off a section big enough to allow the N connector stub and tl to poke through. The sketch below will give you an idea of how much you want to cut off to allo bolt holes to fit when it all comes together.



- Drill a hole in the endcap suitable for the 5/16" bolt. With the side cut off and hole drilled it shou

- All bolted together you should end up with (the picture doesn't show the reflector or N connector

- For the U-bolt mounts I'll leave it up to you as to what size U bolts, 25mm or 35mm or whatever. when you drill the holes to place them in that it's off to the side and the antenna mast won't imped in the N-connector. See the pictures below for how I placed the U-bolts.

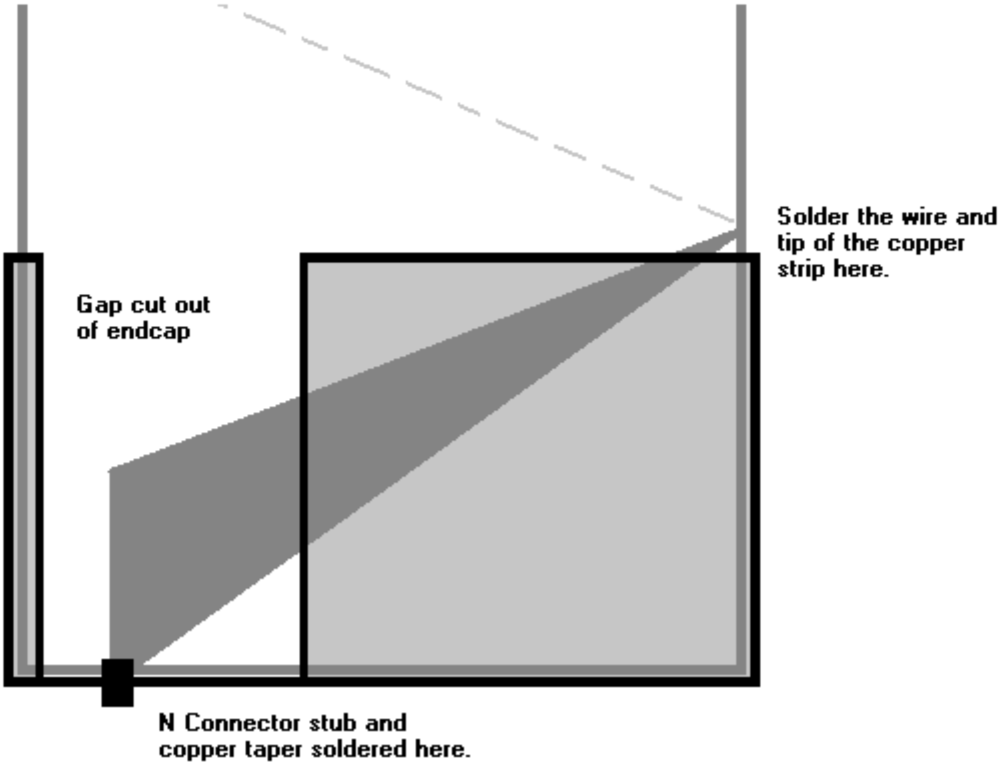
- Place the 130mm brass or aluminium circular sheet on the big 150mm endcap, and bolt on the 40 sure all the holes on the sheet and big endcap line up.

- Attach the N connector.

- In order to match the antenna (from it's nominal 150ohms to the connector's and cables' 50ohm in strip of copper or brass about 15-20mm wide. I happened to have some adhesive copper tape at n length that will follow the marked line where the spiral winds along the tube to the end. It has to of the strip, winding along the spiral until the diagonally opposite corner will poke out above the everything is placed together. Cut the strip in half along the diagonal so you end up with a triang corner. Strip dimensions of the adjacent sides 17mm and 71mm respectively with the hypotenuse Aluminium won't solder so don't bother using that. Brass shim should do the trick though. See on how to measure it up and place it.

- Insert the tube into the 40mm endcap and mark where the spiral meets the top of endcap. Cut the but leave a few mm of excess wire. With the sandpaper, scrape off the enamel off the end of the and easy to solder.

- Carefully solder the narrow pointy end of the tapered strip to the wire and match up where the lov large end will solder neatly onto the stub of the N connector. You might need to use glue or stick place. You might have to do some trimming to get the strip to the correct length. This strip in eff impedance transformer. I don't know quite how it works, but I've done it four times with each str different lengths and according the to two-port analyser it works well.

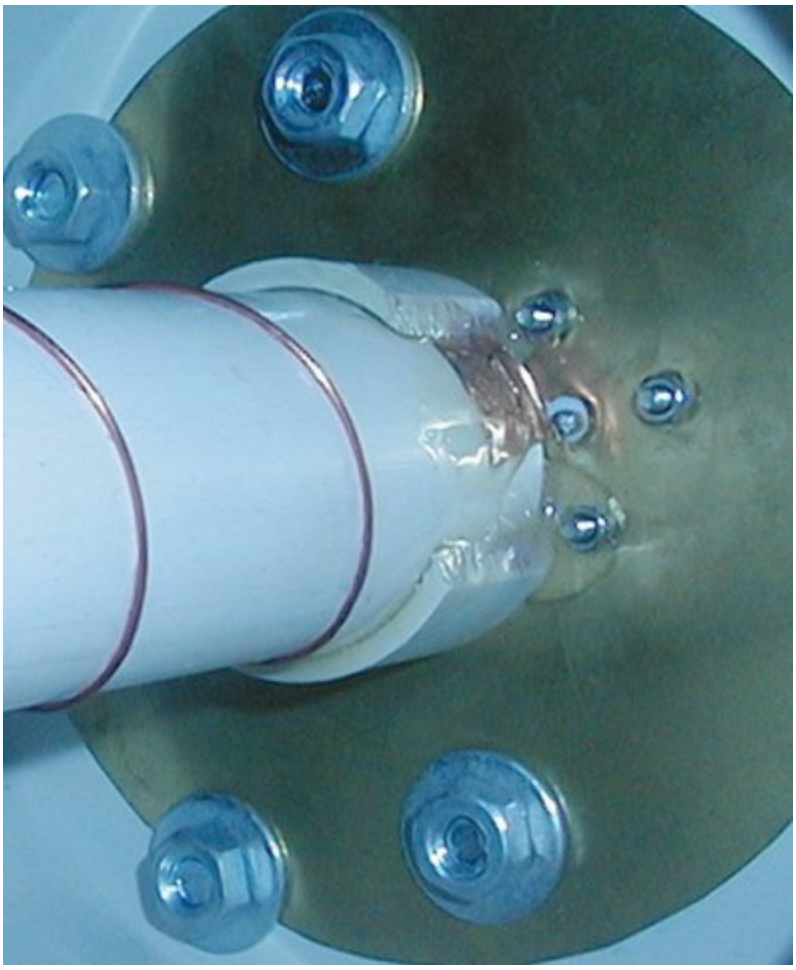


- When the tube is fully inserted into the endcap it should click in place and hold fast. Be satisfied place when wound around so the corner can neatly solder to the N connector stub.

- Take the tube out and with the sandpaper roughen the inside of the 40mm endcap and adjacent su This should help the glue hold better. Before you glue, wipe all the roughened surfaces clean.

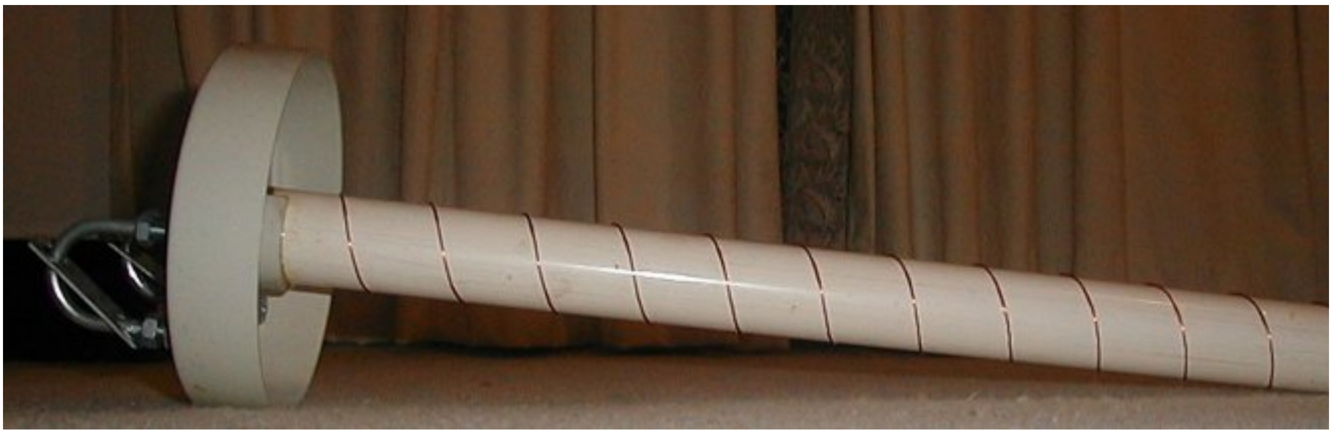
- Get some SLOW DRYING (not 5 min) Araldite and mix up a batch. Apply the Araldite to the tu inside the endcap. Reinsert the tube as described above, aligning the copper strip corner and N c of glue should ooze out. Solder the corner of the taper to the centre pin of the N connector. Mak of glue filling the small gap between the tube and the inner circumference of the endcap.

- Let the glue dry (about a day). Install on the U-bolts and you have yourself a helical! With the ta everything glued up and bolted together you should have something looking like the picture belo connector bolts and centre stub poking through the brass shim. Also visible is the taper corner so and everything covered in globs of dried Araldite.



The reason for the big endcap was so a length of 150mm PVC pipe could slide over the whole assembly the endcap. With another endcap on the other end completely sealing the unit, water and birds would be and it should last longer. If you are going to leave the aerial exposed, make sure you put liberal amount the N connector where the taper solders on and ensure that no water can electrically connect the centre the ground plane (the sheet.) Experience has shown that poor performance in rain and fog due to conde connector kind of shorting out the ground and centre signal pin. I have noticed that the zinc coating on and brass shim had galvanic reactions happening so plastic or rubber washers might be needed instead deterioration of the brass.

Here is a picture of the finished product!



And from the back.

Important Stuff

- The PVC tube I used didn't get hot in the microwave oven even after two minutes, so it shouldn't from the WaveLAN. Test your tube (or other tube shaped materials you will use as an aerial winc metal)) in the microwave for a minute (with a small glass of water too) and make sure it doesn't g does, it's no good for making an aerial with.

- The matching section described above worked for me in several incarnations, all of which were a when the two port analyser told indicated how well the matching circuit worked.

- Until I do some more testing, I won't make any claims that this aerial should work to 10Kms (tho and it's the maximum range intended). They do work well to 3-4Km with a good line of sight (nc like trees and house roofs).

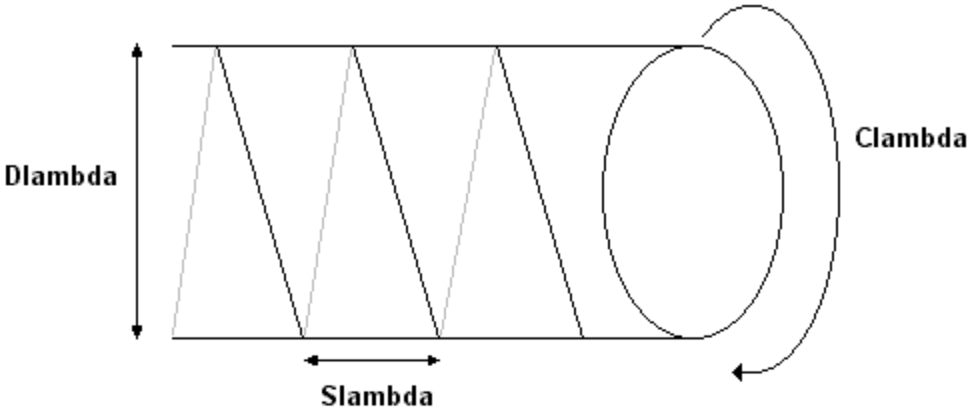
- Possible variations on this aerial design abound. You'll have to use your imagination to come up variations. Using single sided unetched printed circuit board for the backplane is one, as the fibre strong and the copper is already bonded to the board which you can use as the reflector.

Theory

The design for this aerial was derived from the good ol' ARRL Antenna Handbook. From chapter 19 ar designs and some maths detailing how to paramterise and gauge the performance of the aerial.

I have lost my original design notes, so I am rederiving this from the PDF files and measuring the aerial

The following formulae are from page 19-23 of the ARRL Antenna Handbook. I am repeating them he has access to this book.



$C_\lambda = 0.75\lambda$ to 1.33λ - circumference of winding
$S_\lambda = 0.2126C_\lambda$ to $0.2867C_\lambda$ - axial length of one turn
$G_\lambda = 0.8\lambda$ to 1.1λ - diameter of ground plane / reflector
$C_\lambda = \pi D_\lambda$ - circumference is pi times the diameter

The diameter of the winding is fixed, with the PVC tubing being 42mm in diameter.
The centre frequency (2.425GHz) has a wavelength **l** = 0.123711 metres.

$C_\lambda = \pi * 0.042m = 0.13195m$
$= 1.066$

Looking back at the measurements, I may have screwed up somewhere because Sl seems to be 0.31830
range of the specified values. I don't know how this came to be, but it doesn't seem to be too big an imp

$S_\lambda = 0.3183 * 0.13195m = 0.042m$ (strangely enough, the diameter of the tubing.)

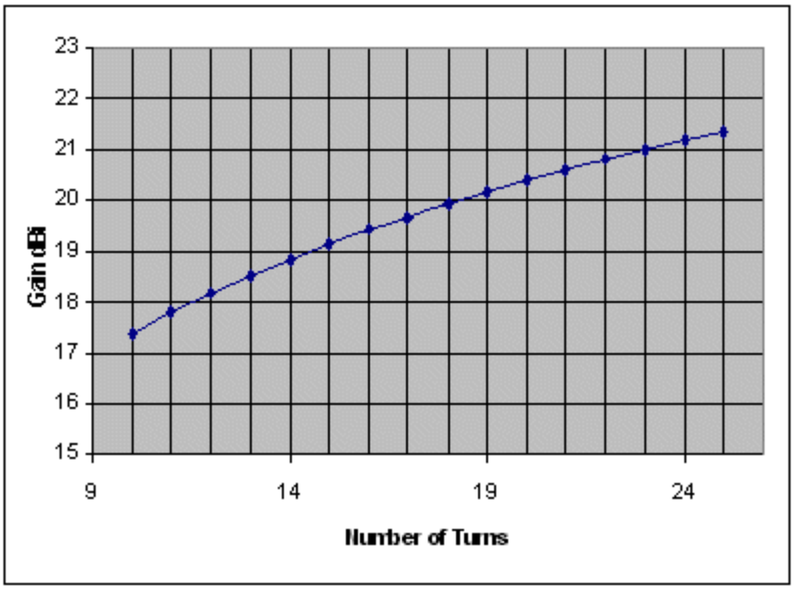
The ground plane diameter $G = 1.05\ \lambda = 0.130m$

The gain of the aerial in dBi is defined as:

$Gain = 11.8 + 10*\log_{10}(C_\lambda * C_\lambda * n * S_\lambda)$ where n is the number of turns.

$Gain = 11.8 + 10*\log_{10}(1.066 * 1.066 * 13 * 0.31830)$
$= 18.5dBi$

The chart below shows the amount of gain to be had for the number of turns. As you can see, to get abc
you have to double the number of turns and double the length of the aerial. Thirteen turns happens to fi
good compromise for length versus gain.



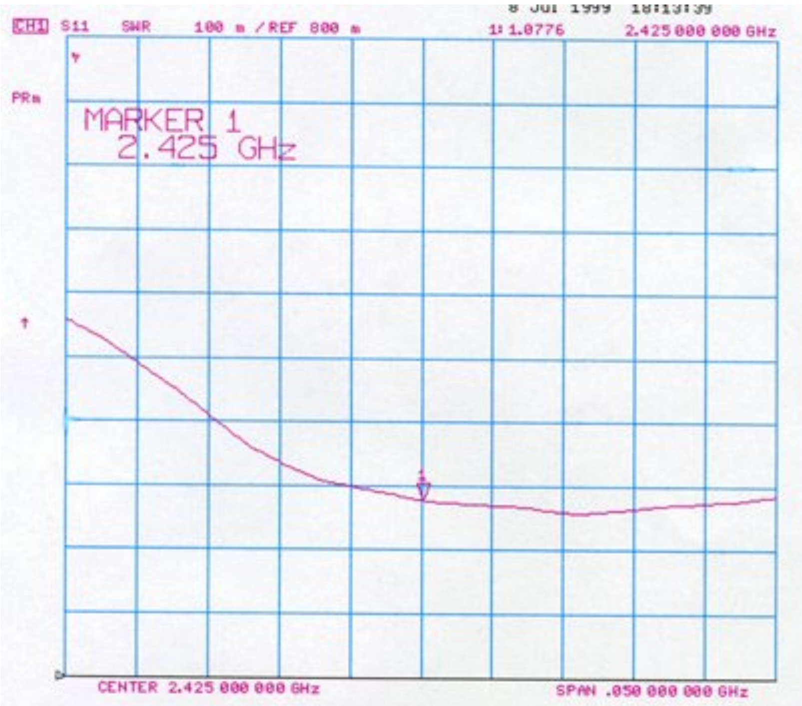
A lot of the newer 802.11 cards allow for a selection of centre frequencies (channels). You might want t dimensions by using the above formulae to calculate new C_λ and S_λ.

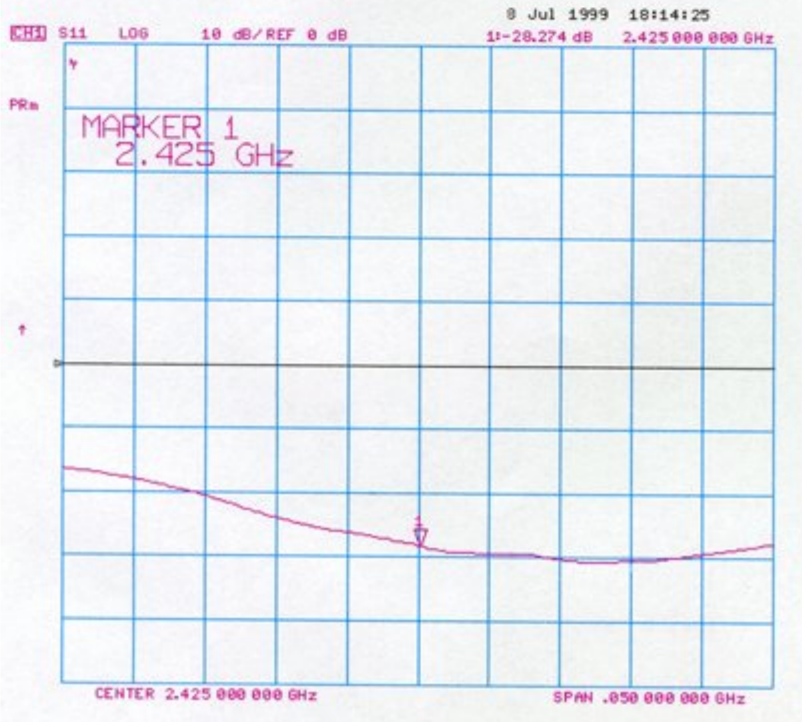
Some people (namely some ham radio types who know what they are doing) have built the antenna and wasn't as good as the theory suggests. I assume that they built the antenna properly and had good imped page suggests that helicals could have their gains overestimated by the standard Kraus formula (as used 4-5dB. This would have a severe effect on calculated link budgets, especially marginal ones. If anyone i ideas on this or some empirical evidence, please get in contact with me.

Performance

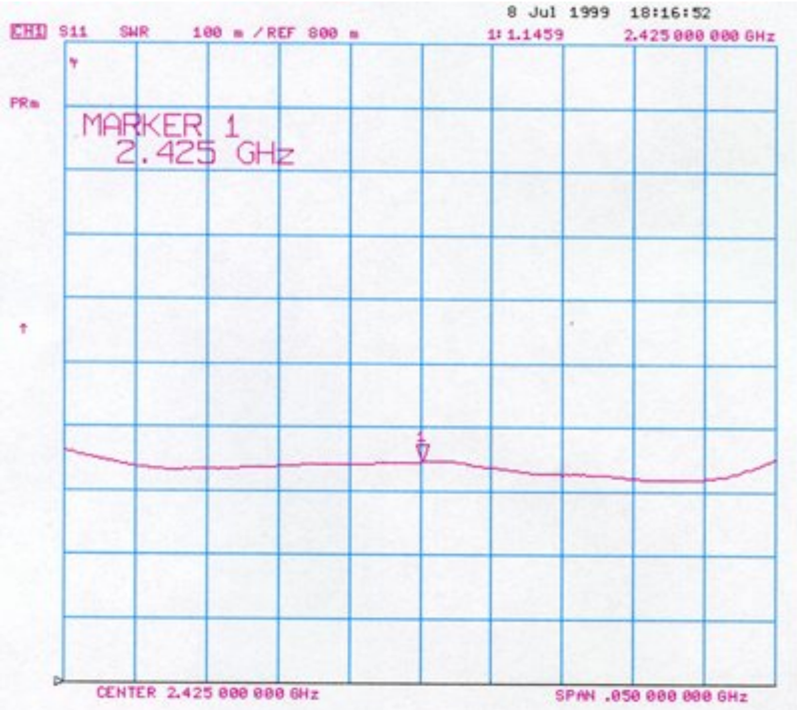
I have measured the efficiency of these aerials by measuring the S11 parameters. Below are measureme constructed. The upper diagram is the SWR measurement, and lower is the log return measurement. B good and have the broadband required for spread spectrum communications (SWR of 1:1.15 or better!). ad-hoc aerial matching strip actually works extremely well! I have yet to test the performance over dist

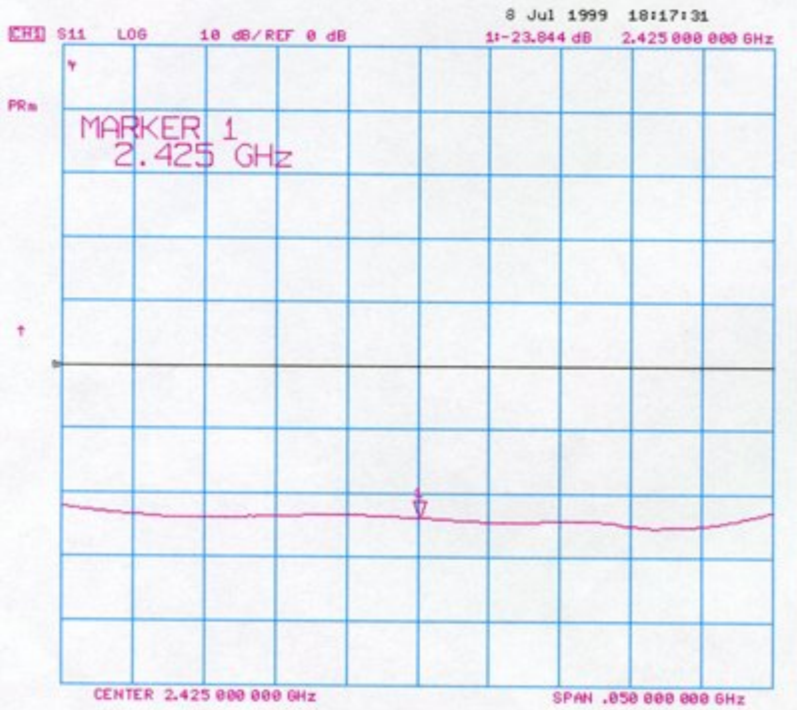
Aerial #1


8 Jul 1999 18:13:39
CH1 S11 SWR 100 m /REF 800 m
1: 1.0776 2.425 000 000 GHz
PRm
MARKER 1
2.425 GHz
CENTER 2.425 000 000 GHz
SPAN .050 000 000 GHz


8 Jul 1999 18:14:25
CH1 S11 LOG 10 dB/REF 0 dB
1:-28.274 dB 2.425 000 000 GHz
PRm
MARKER 1
2.425 GHz
CENTER 2.425 000 000 GHz
SPAN .050 000 000 GHz

Aerial #2





Beam Patterns

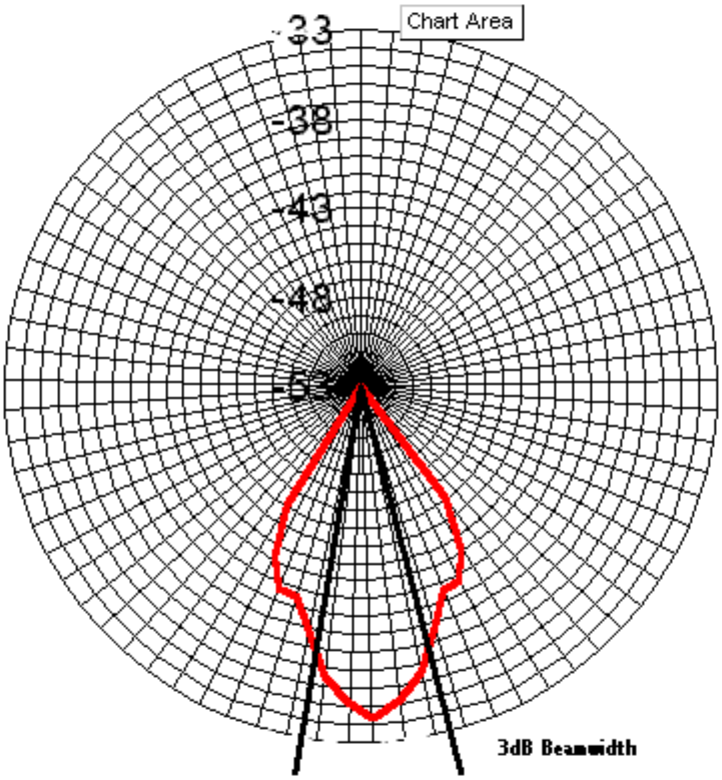
Below are some beam pattern measurements. Unfortunately due to the setup I was only able to measure degrees. The first beam pattern was sampled at 5 degree intervals for 40 degrees and mirrored to give a -3dB points as marked agree with the theory that the beam is about 25 degrees wide. The second beam with 10 degree intervals used over 90 degrees. This clearly shows the first null at about 40 degrees off t ratio between the main beam maximum and side lobe maximum was about 10dB. The front to back rat 20dB.

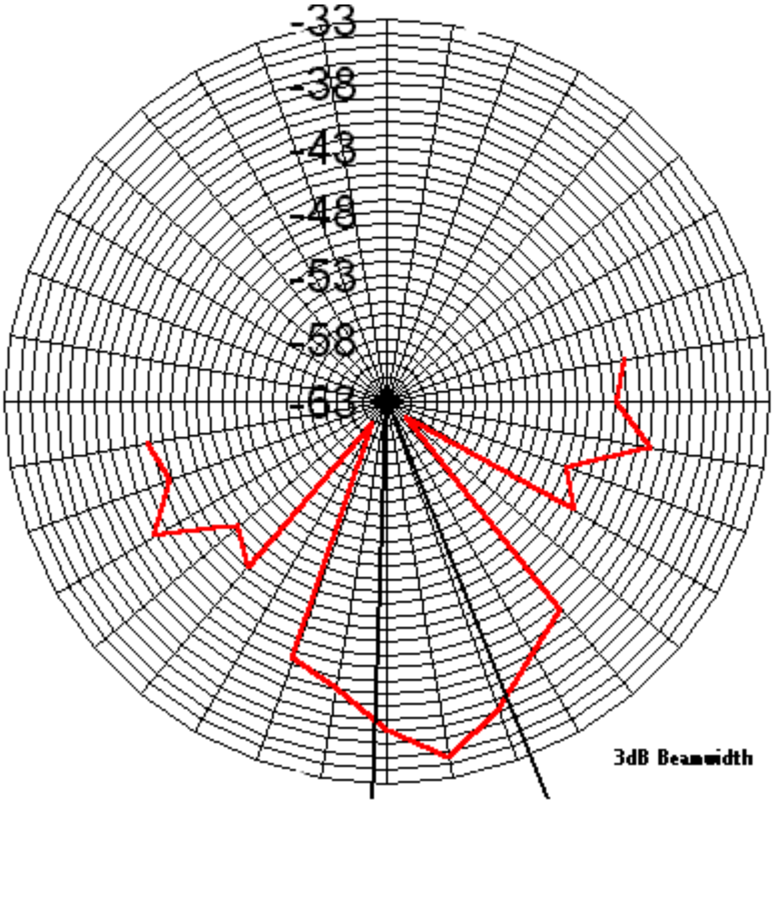
Half Power Beam Width

$= 52 / (C_\lambda * \text{sqrt}(n * S_\lambda))$ degrees

$= 52 / (1.066 * \text{sqrt}(13 * 0.31830))$

$= 23.98$ degrees





Credits

Thanks to Mark Hulskamp for photos and his assistance. Thanks also to Ramon Donnell for some of the
CEA Technologies (where I worked at the time) for the use of their fancy and expensive HP network an

Links

Michael Borthwick used this antenna design to track the video of the launch of his model rocket.