Loop on the Ground receive antenna

Notes based on KK5JY's "The Loop on Ground antenna" webpage http://kk5jy.net/LoG/

This a wire loop receive antenna placed directly on the ground.

Its great advantage is that you can't see it

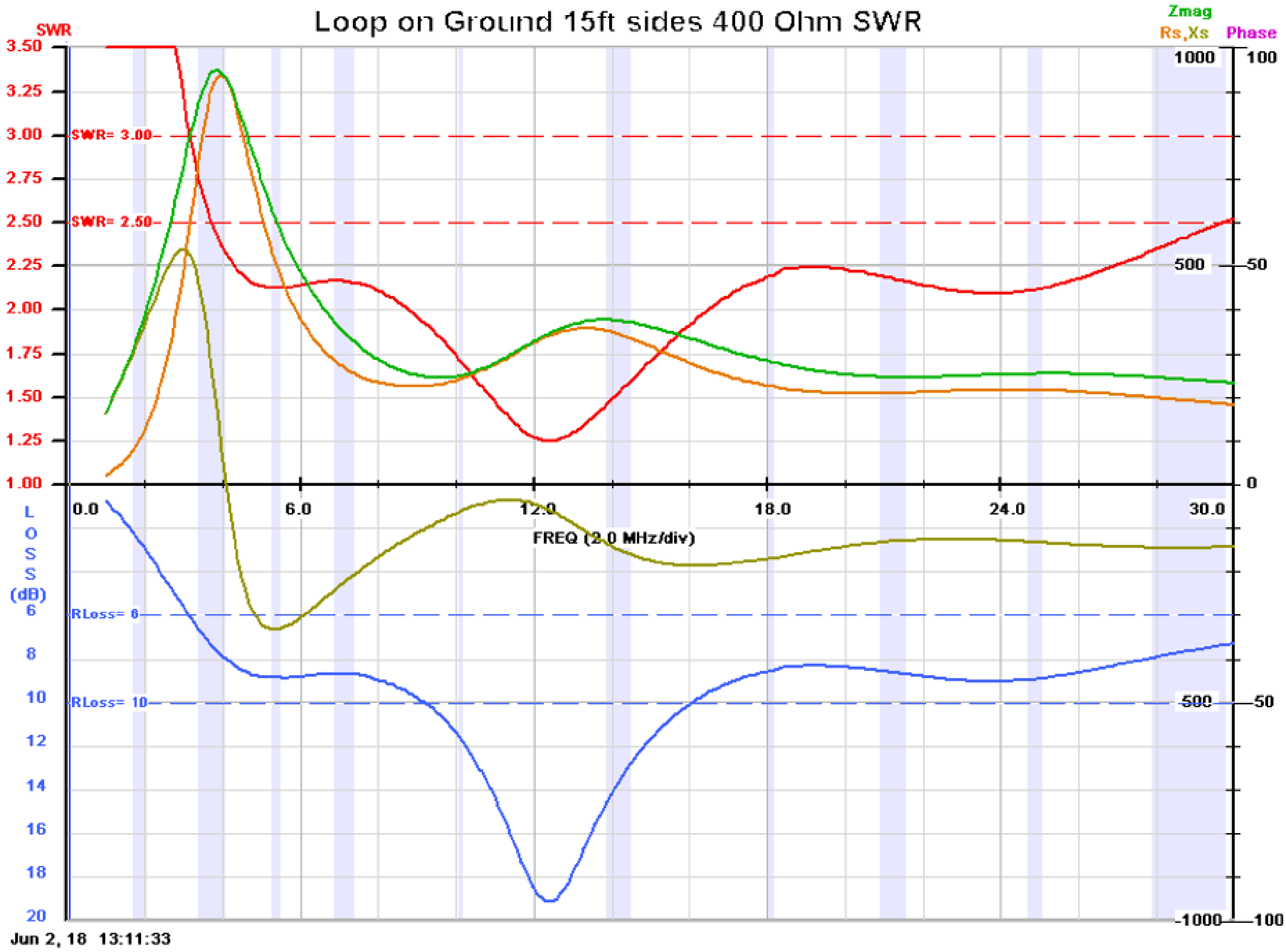
The loop is made from insulated wire laid directly on the ground and fed at one corner with a 400 to 50 Ohm broadband isolating transformer

Maximum directivity is at right angles to the feed point.

I found that it was advantageous to raise the loop off the ground slightly, as this dramatically improved the performance on the HF bands.

I'm using cheap electric fence support poles to allow me to easily adjust the height for tests.

The loop feed point impedance is approx 400 Ohms.


Loop on Ground 15ft sides 400 Ohm SWR
SWR
Zmag
Rs,Xs
Phase
SWR= 3.00
SWR= 2.50
LOSS (dB)
RLoss= 6
RLoss= 10
0.0
6.0
12.0
18.0
24.0
30.0
FREQ (2.0 MHz/div)
Jun 2, 18 13:11:33


Loop on Ground 30ft sides 400 Ohm SWR
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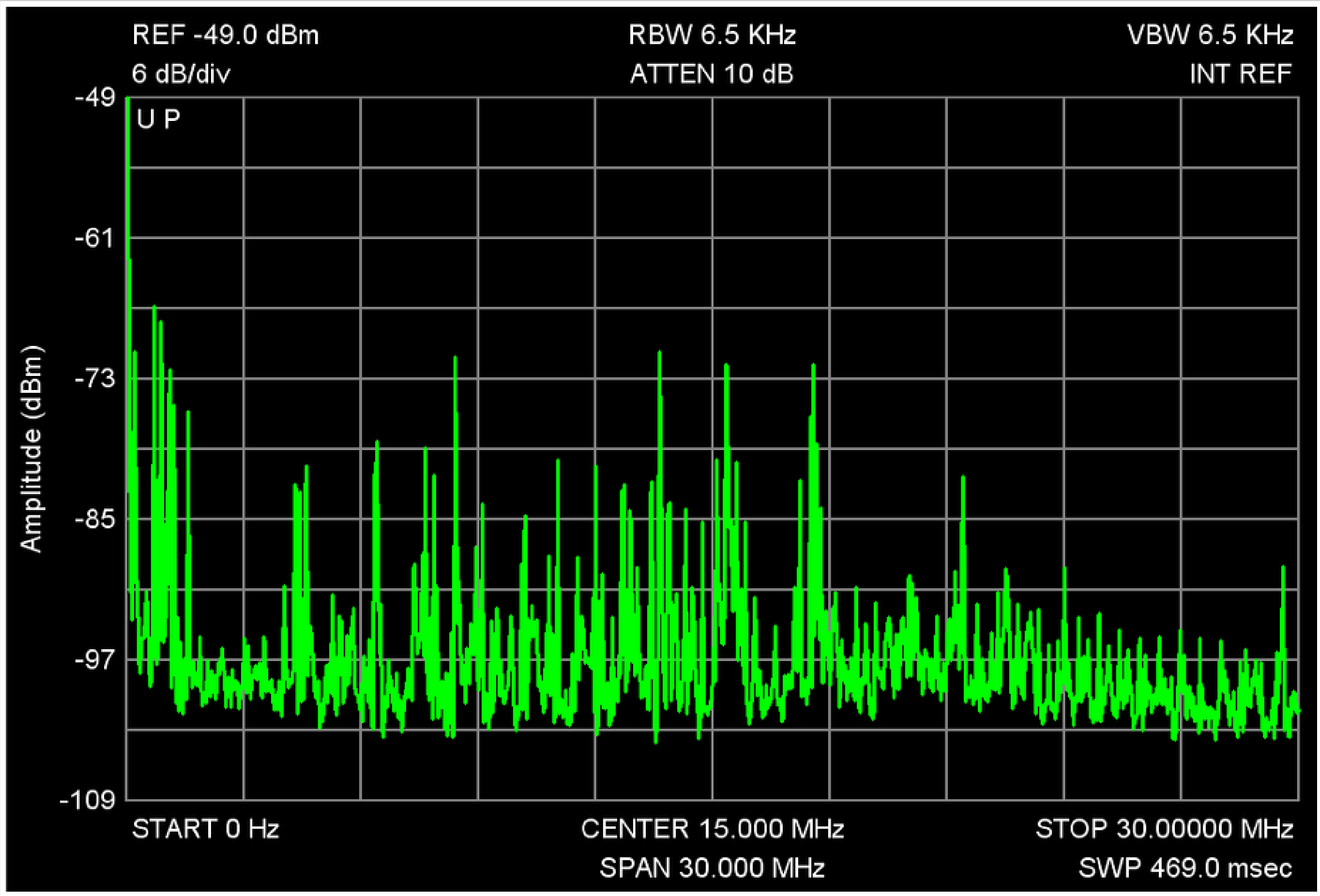
0.0
6.0
12.0
18.0
24.0
30.0
FREQ (2.0 MHz/div)
Jun 2, 18 13:28:07

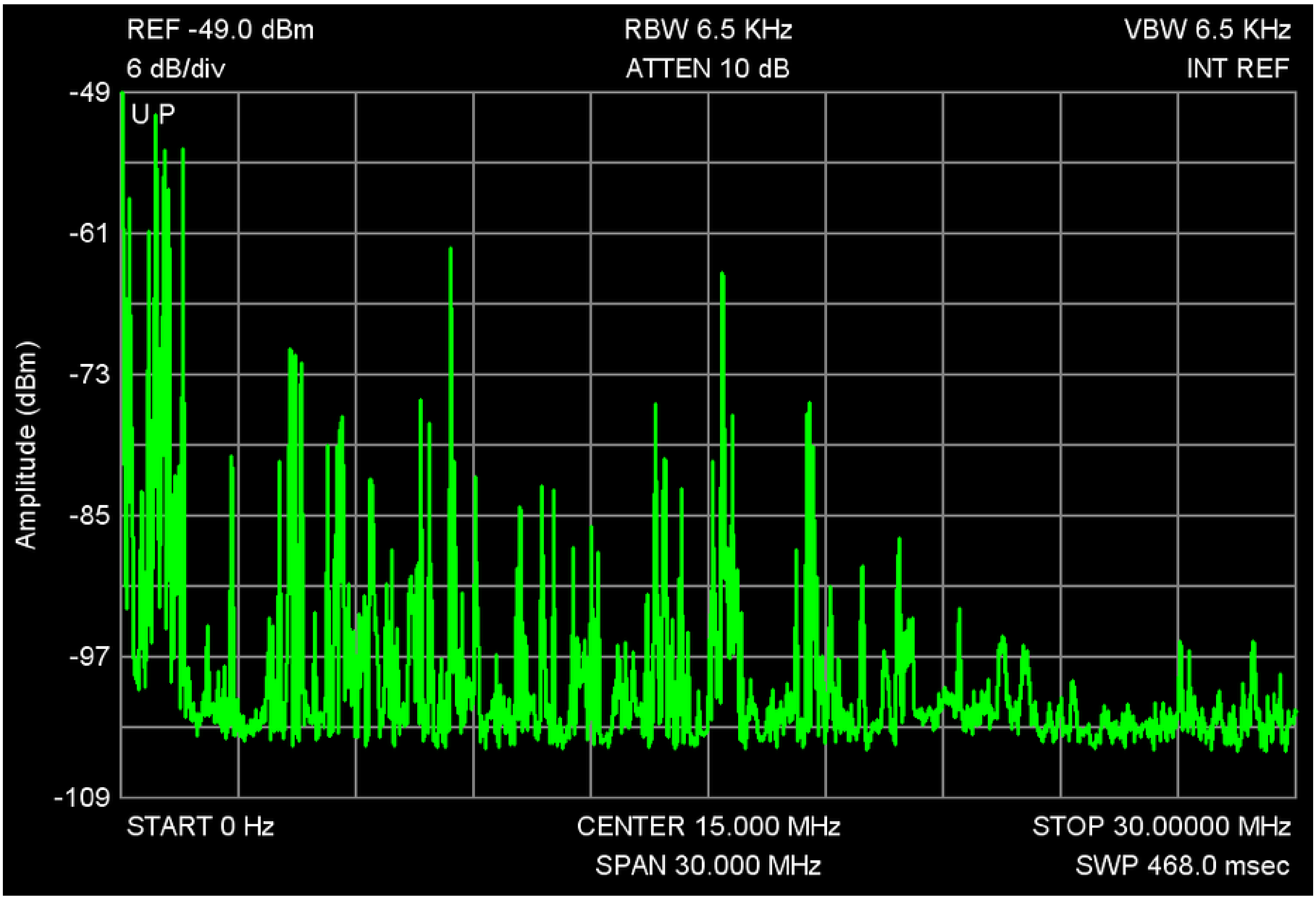
The sensitivity at the lowest operating frequency is determined by the loop size;.

Being mounted so close to the ground the gain is quite low, typically -20dBi, however the S/N is very good and the gain can be made up by use of a suitable amplifier.

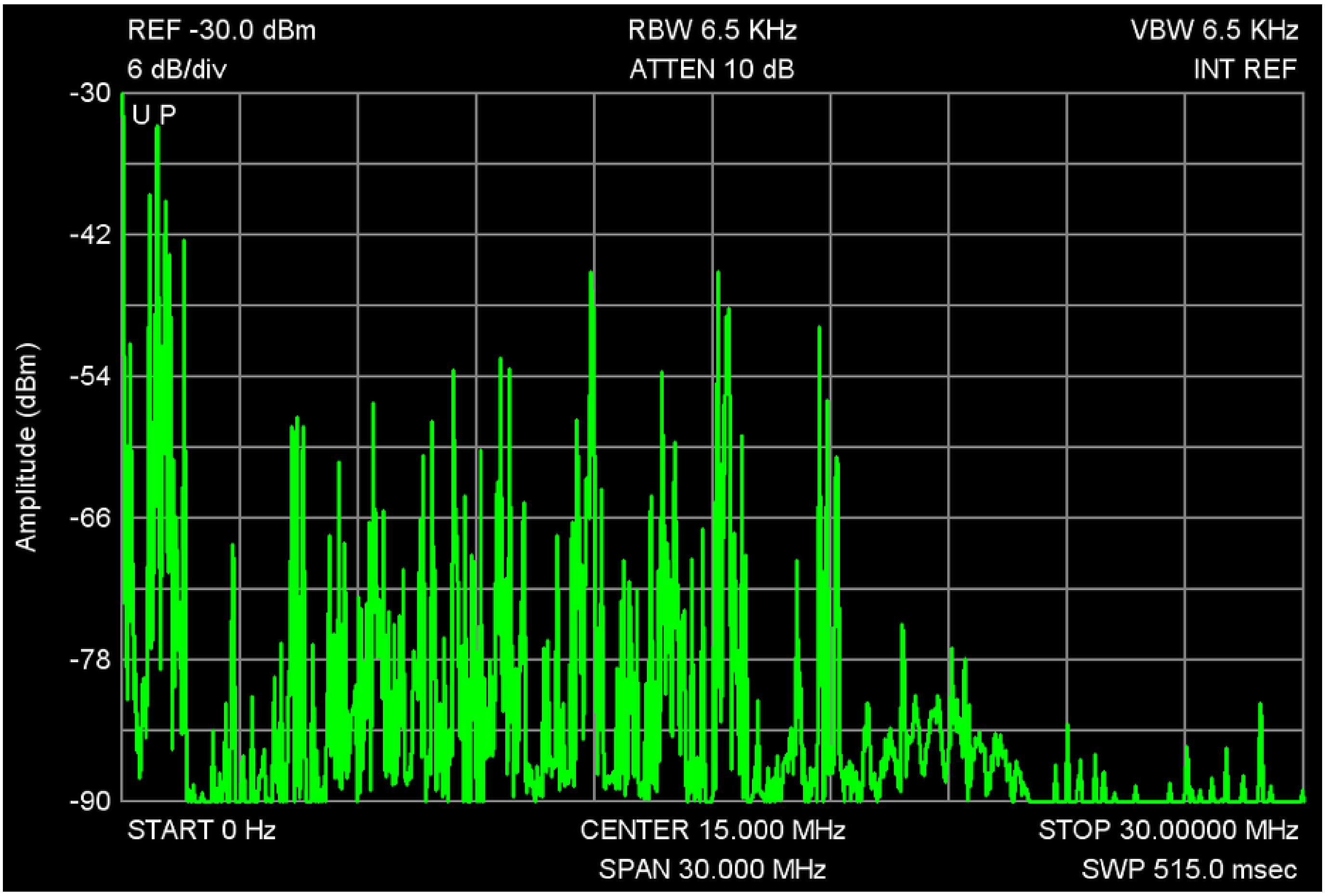
15ft loop signal amplitude measured via 450:50 Ohm transformer no pre-amp



30ft loop signal amplitude measured via 450:50 Ohm transformer no pre-amp



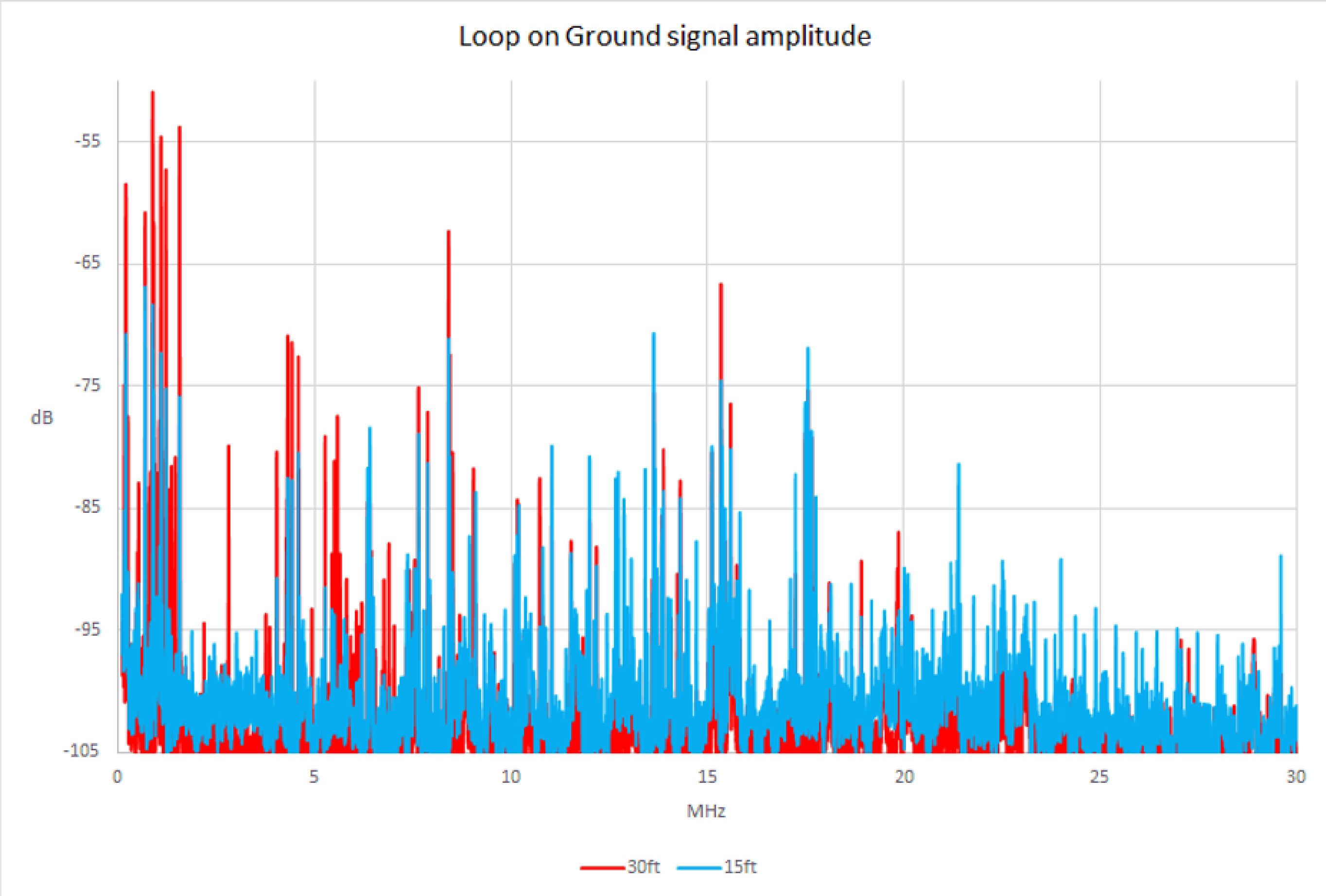
Levels from TC2M broadband vertical antenna (for reference purposes).



This suggests that approx 20dB pre-amplifier gain is required to bring the loop signal levels up to match those produced by a typical full size doublet or vertical antenna.

It is better to place a pre-amplifier at the antenna feedpoint in order to minimise unwanted noise pickup along the feed cable.

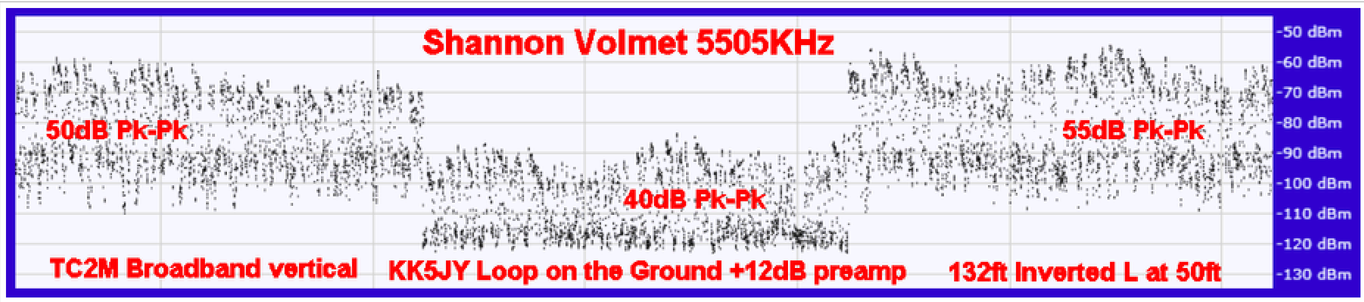
The next graph shows the signal levels from the 30ft and 15ft loops overlaid on top of each other.



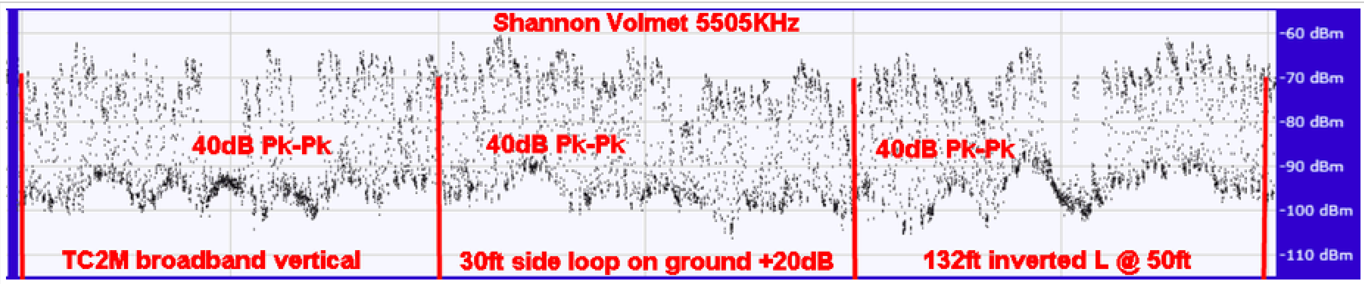
Graph showing the difference in signal levels between the 30ft and 15ft sized loops.

Note that variations in propagation between the positions of the two loops account for the increase in negaitive values on frequencies above approx 7MHz.

Shannon Volmet with 15ft loop with 450:50 transformer and 12dB pre-amp



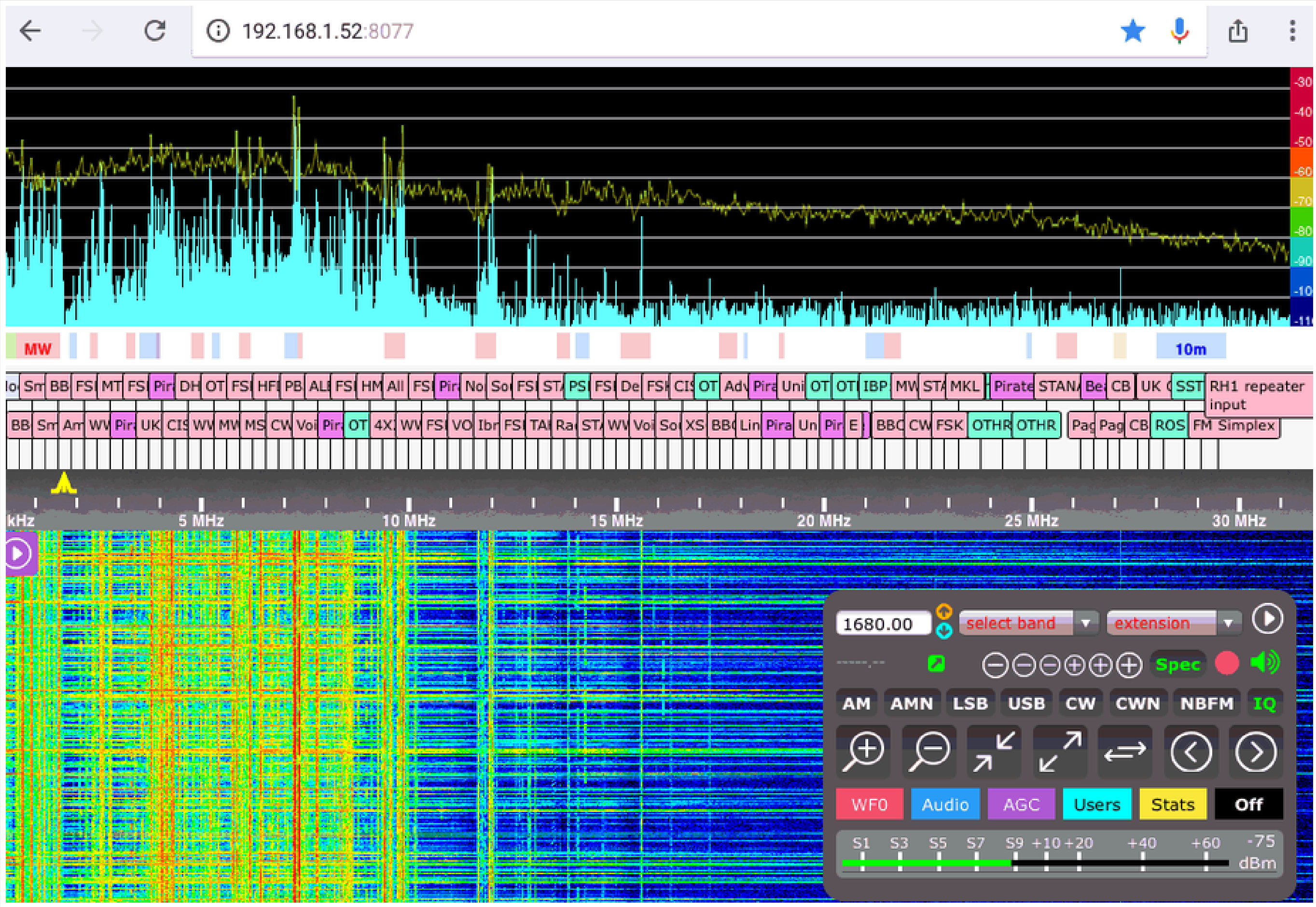
Shannon Volmet with 30ft loop with 450:50 transformer and 20dB pre-amp (note static crashes have increased the noise floor)



During a major thunderstorm I was able to use my KiWi SDR to take a look at the distribution of RF energy across the spectrum in order to assess the frequency response of the antenna.

If you look at the top half of the display you can see the yellow 'peak hold' line and the cyan spectrum with no noise burst.

Assuming the energy distribution is linear across the frequency range (which it probably isn't) then the loop is not too bad as a broadband RX antenna, apart from the obvious amplitude slope.



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Antenna configuration

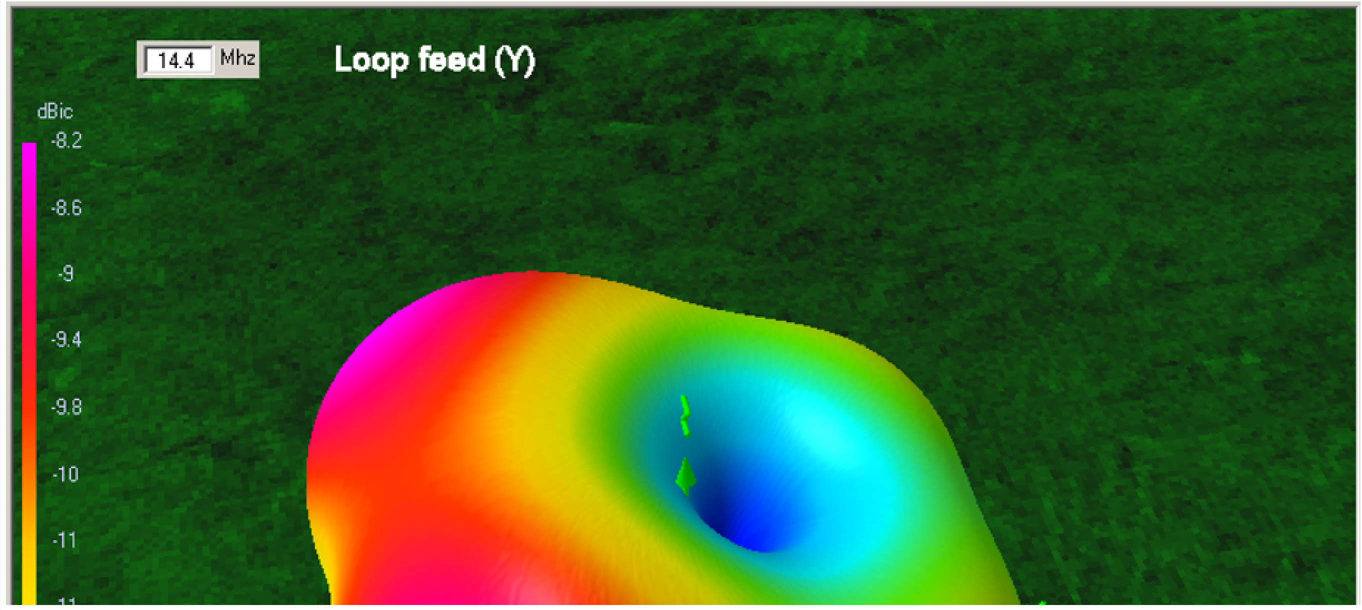
A 10m side loop antenna mounted 10cm (0.1m) above the ground has a radiation pattern that is omni-directional up to approx 10MHz and the bulk of the gain is directly upward, so it provides good NVIS performance.

On frequencies greater than 10MHz the pattern forms into a single and then multiple lobes. A null in the pattern forms on the side of the loop with the feed point connection.

Open Circuiting the loop opposite the feed point and placing a termination resistor opposite the feed point modify the pattern, but the best results are obtained with it configured as a standard loop.

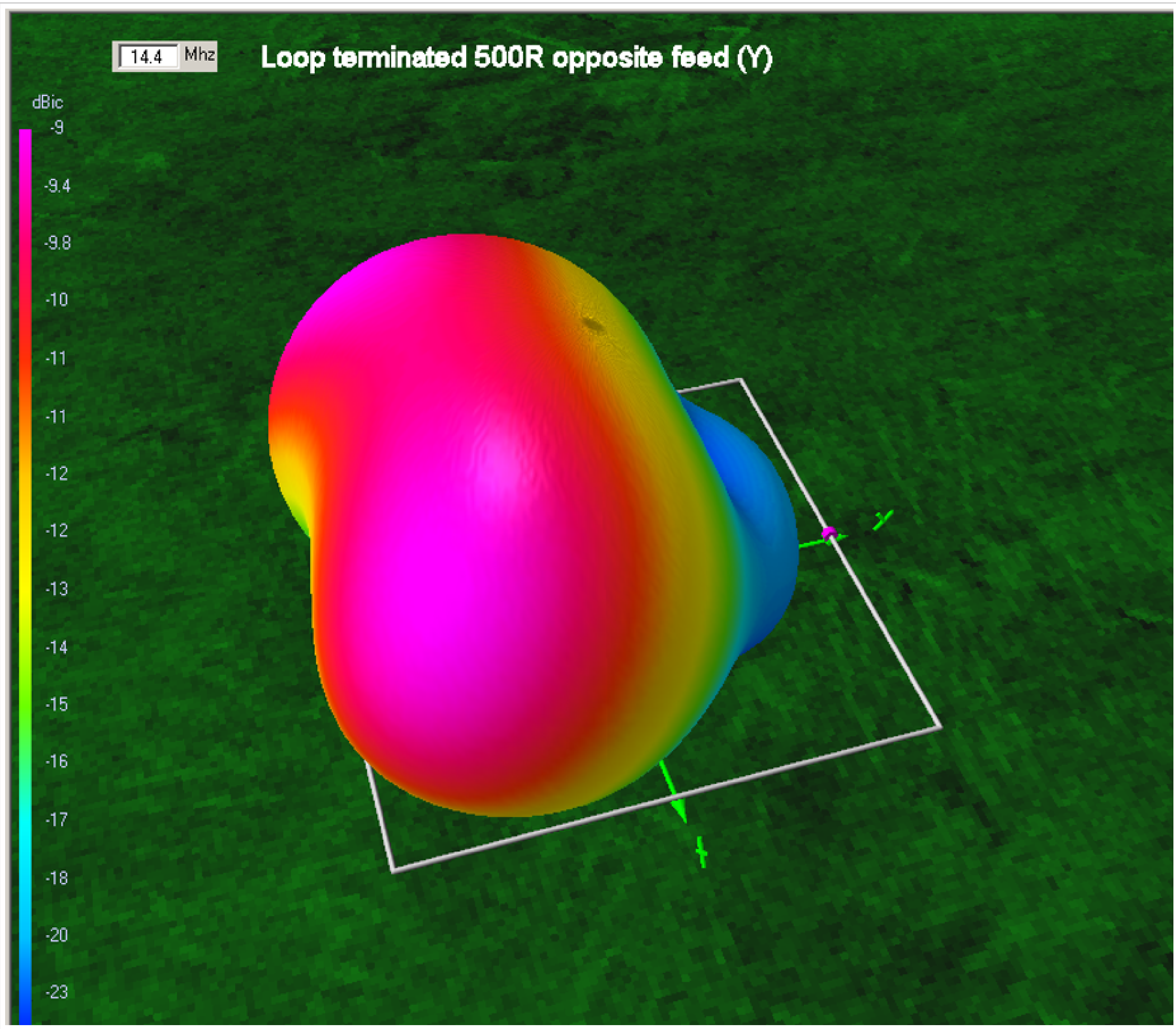
Here are some plots with the feed point 1/2 way along one side of the loop, as this seems to provide the best overall radiation pattern on all frequencies.

The first one shows the normal loop pattern, which is fairly low angle and omni-directional.



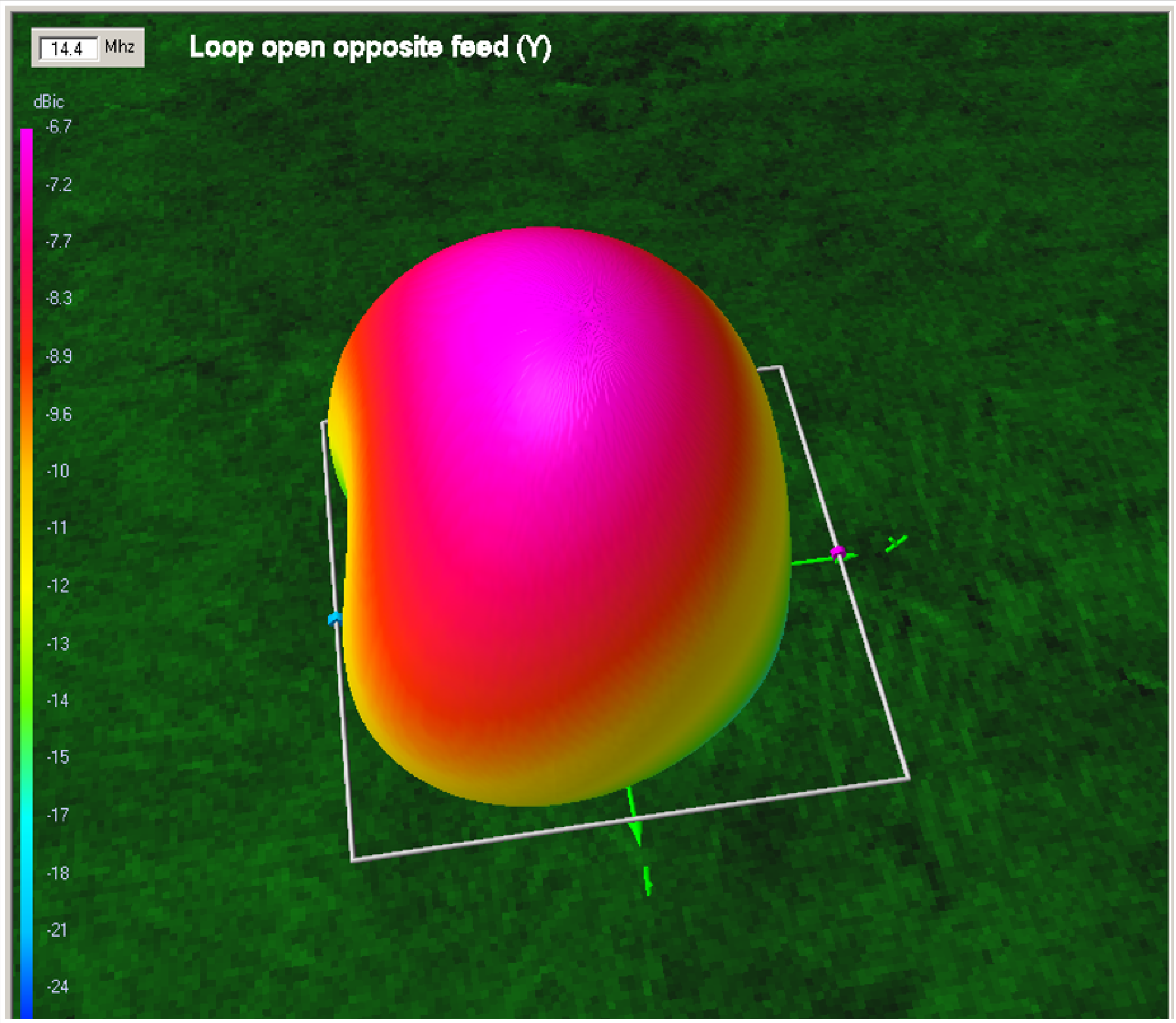
The next shows the loop with a 500R terminating resistor connected opposite to the feed point.

This produces a lobed pattern with high angle radiation, which is not desirable on the HF bands.



The final plot shows the loop with an open circuit opposite to the feed point.

This produces a very high angle radiation pattern, which is not desirable on the HF bands.



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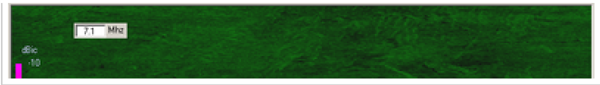
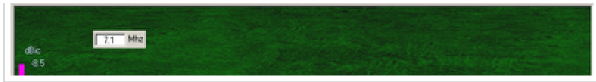
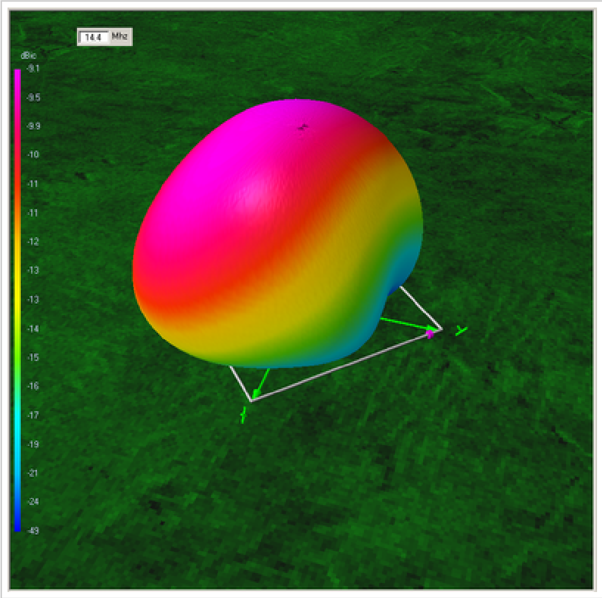
Loop feed point

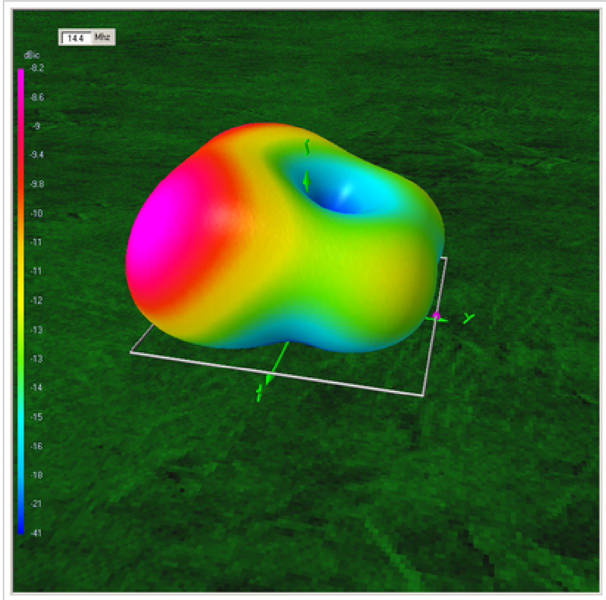
The position of the loop feedpoint affects the overall pattern.

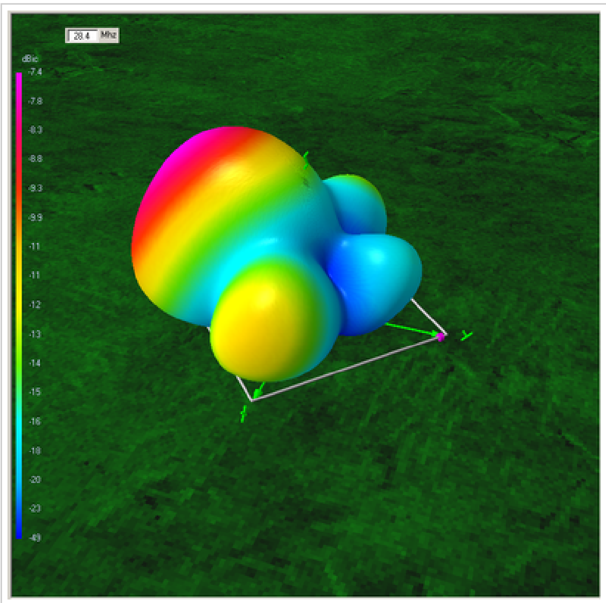
Feeding at a corner or halfway along one side makes a significant difference to the overall pattern, especially on frequencies above 10MHz.

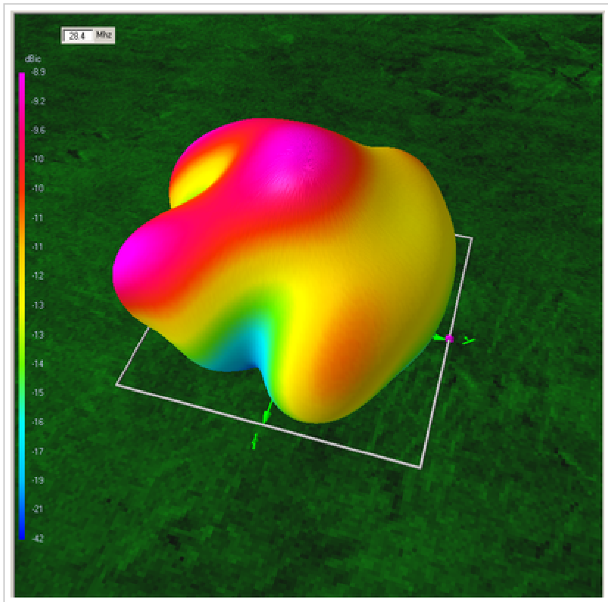




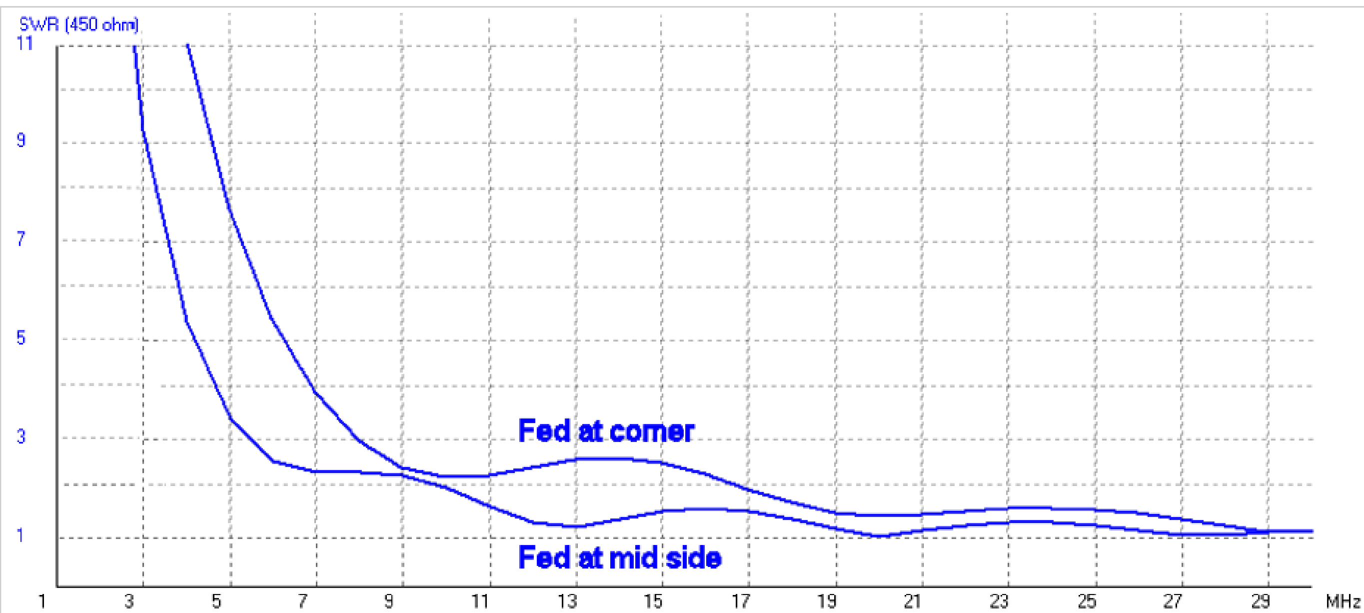








The 450 Ohm SWR of both feed methods is very similar, but the loop fed at the middle of one side is slightly better.



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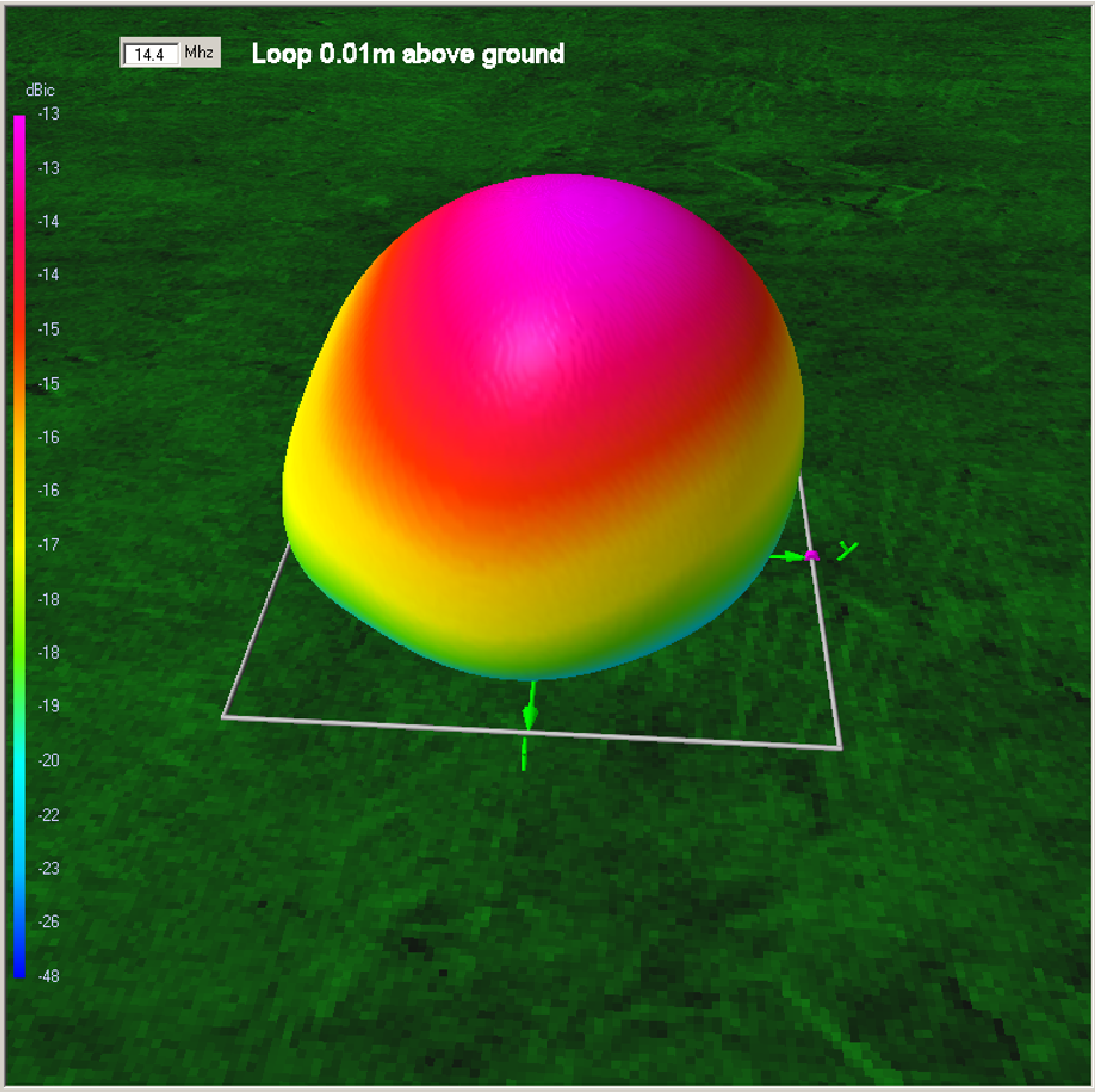
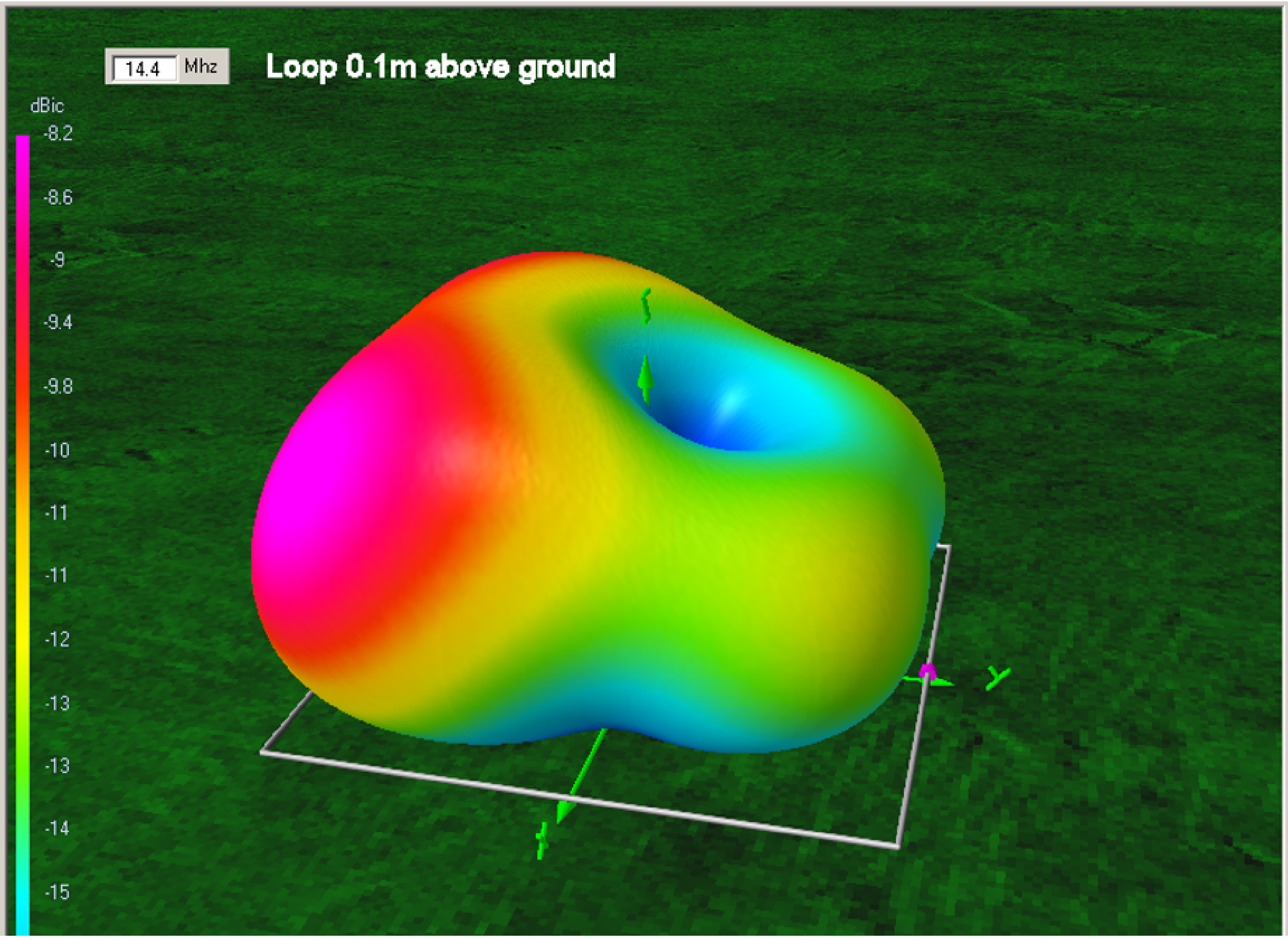
Loop Height above ground

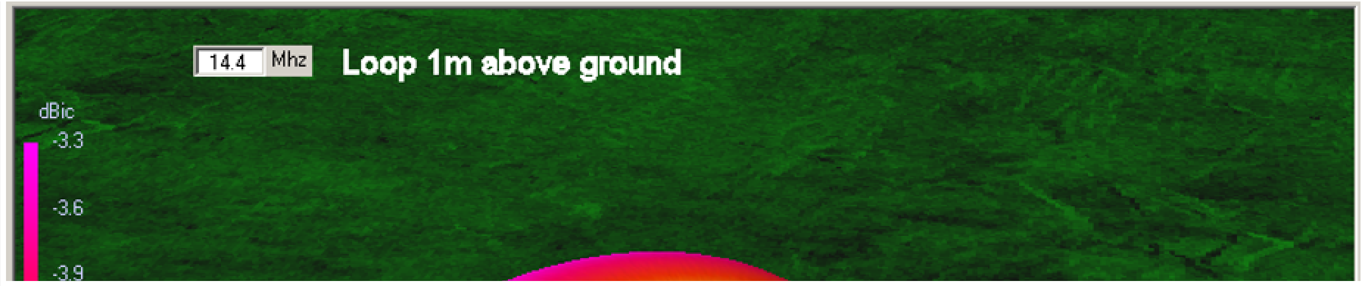
The height of the loop is fairly critical on frequencies above about 10MHz. A loop that is mounted on, or just above the ground will tend to have a greater amount of radiation directly up towards the sky. Although upwards radiation can be helpful on the LF bands as it facilitates NVIS propagation, it is not desirable on the HF bands, where the radiation pattern should ideally be out towards the sides and horizontal as possible.

Lifting the loop approximately 10cm (0.1m) above the ground makes the most noticable difference to the pattern. Increasing it still further improves the gain and omni-directional pattern, but this may be at the expense of an increased noise level.





14.4
Mhz
Loop 0.1m above ground
dBic
-8.2
-8.6
-9
-9.4
-9.8
-10
-11
-11
-12
-13
-13
-14
-15
Y

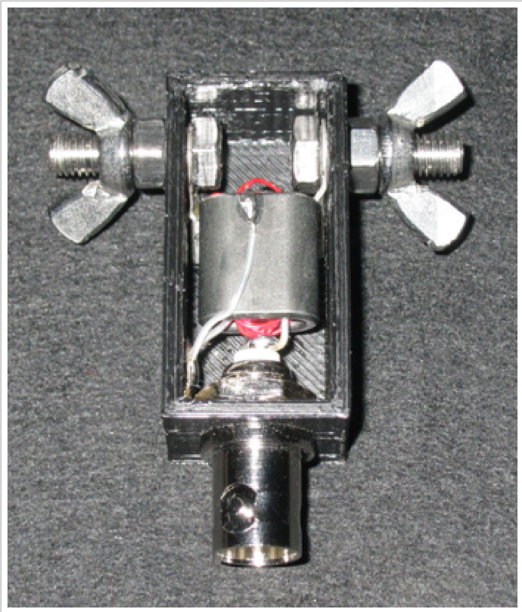


Matching transformer

The transformer consists of a 12 turn 450 Ohm primary and 4 turn 50 Ohm secondary wound through a BN 73-202 binocular core.

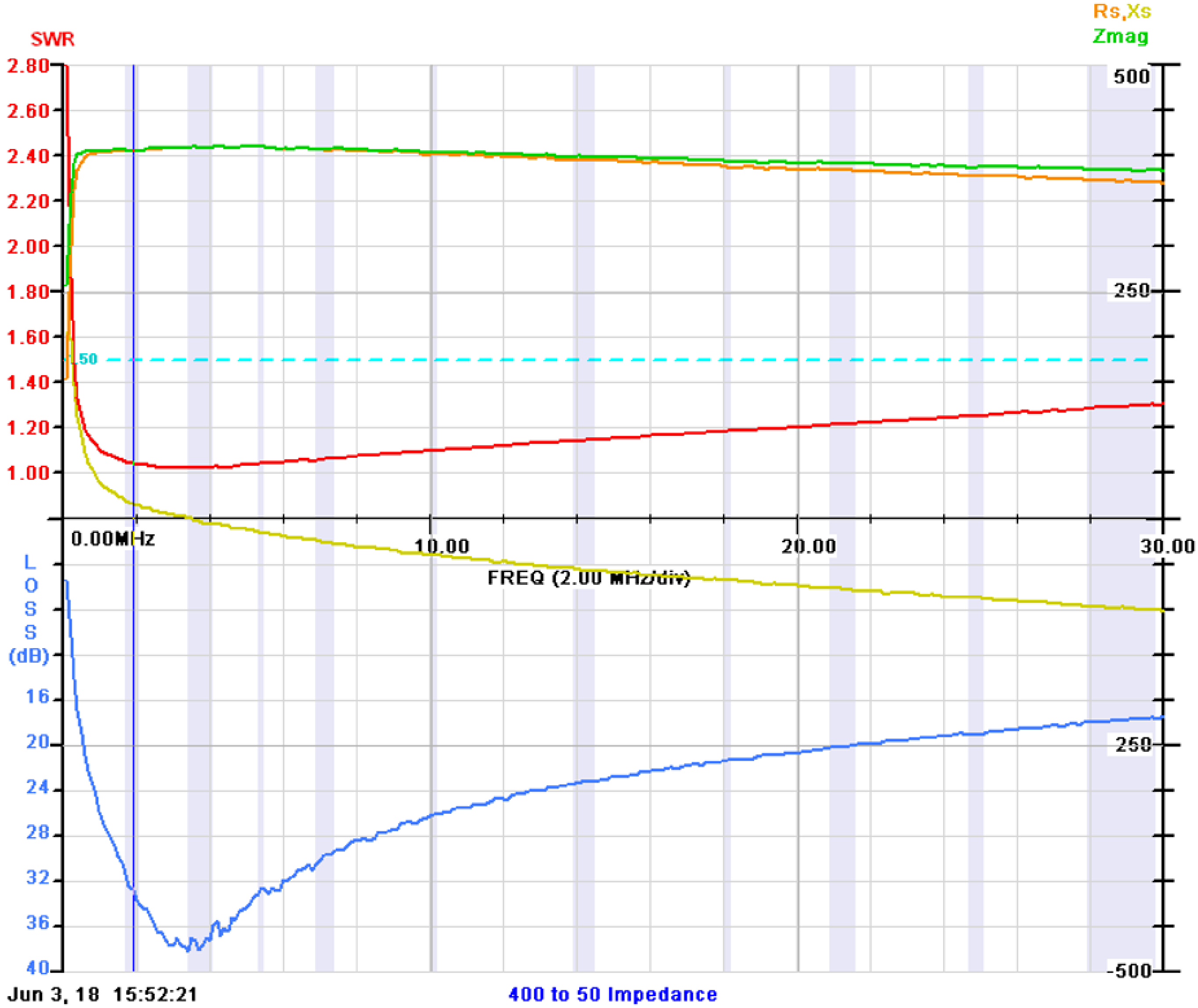
I originally used a grounded center tap on the primary winding, but this introduced too much unwanted noise, so I disconnected it to provide galvanic isolation between the primary and secondary windings.

This can be clearly seen in the Spectrum Analyser signal measurements shown further down the page



This provides a flat impedance transformation ratio with less than 0.5dB insertion loss from 1MHz to 30MHz.

The graph below shows the impedance and SWR measured on the 450 Ohm primary with the 50 Ohm secondary terminated with a 50 Ohm resistive load.



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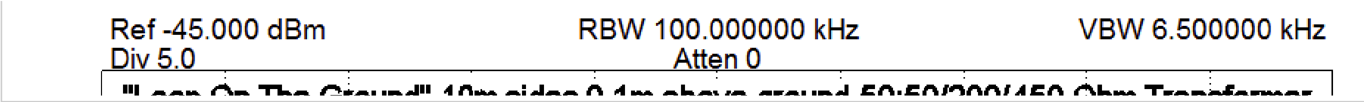
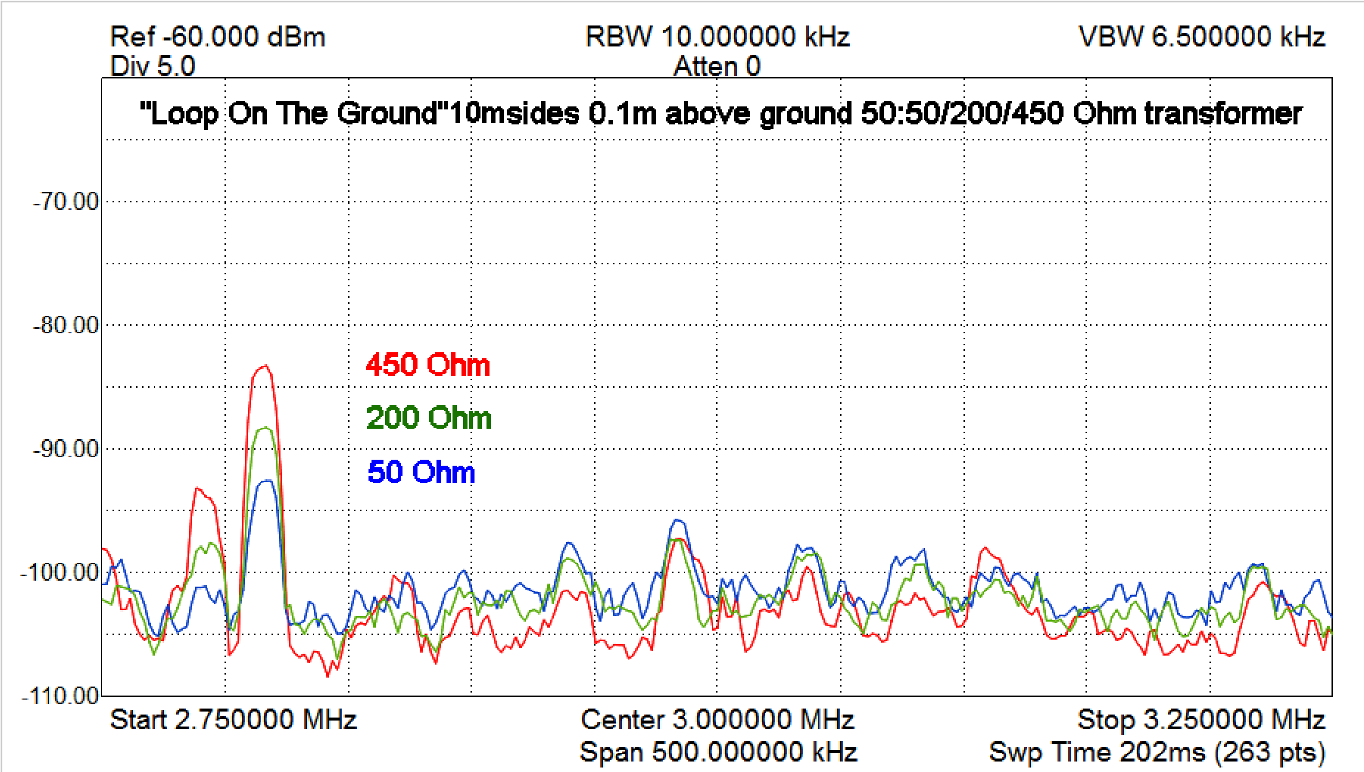
Spectrum Analyser signal measurements

450 Ohm termination impedance provides the best S/N and interference rejection.

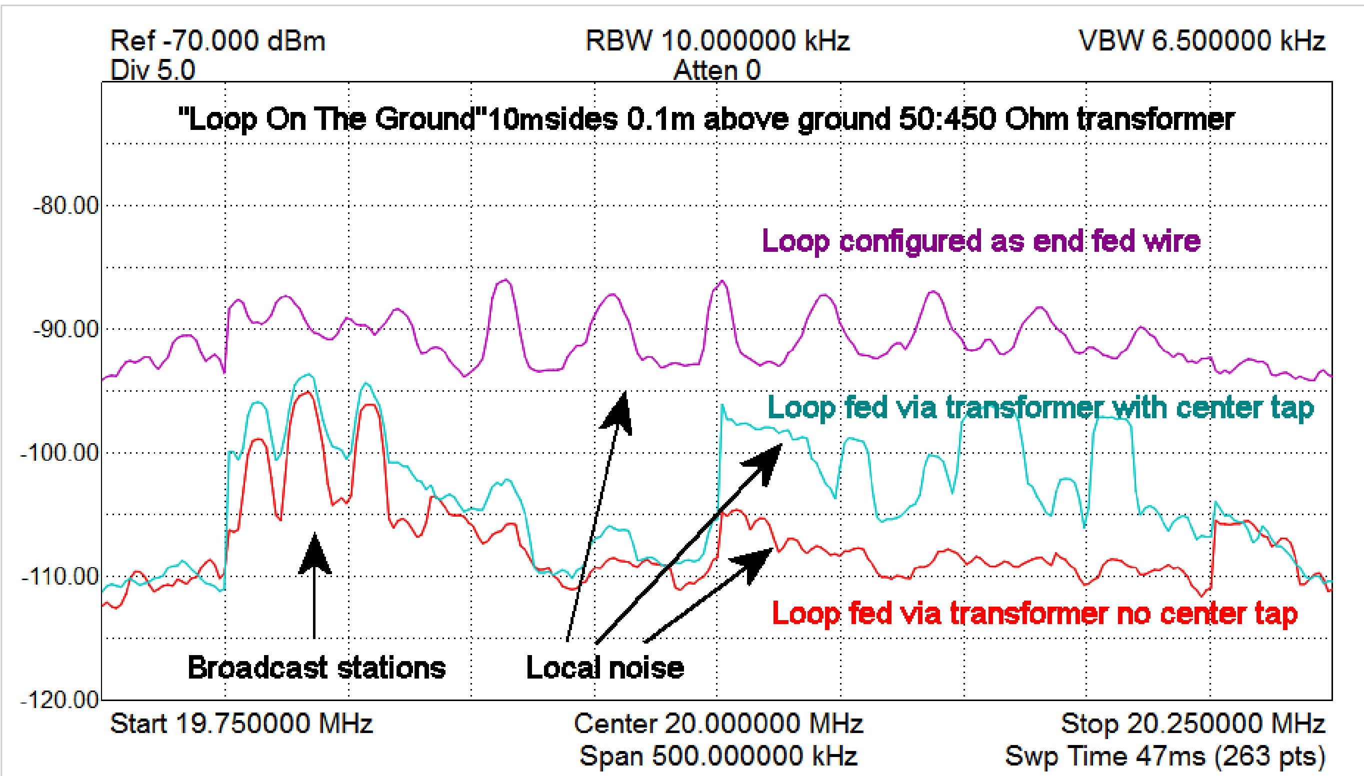




There is a source of unwanted broadband electrical noise approximately 100m away from the antenna site, which causes problems with some types of antennas.

When the loop was configured as an end fed wire (one end of the loop disconnected from the amplifier) the noise floor was considerably higher than when configured as a loop.

A transformer with a center tapped primary provided some interference rejection, but removing the center tap improved the noise rejection still further, as can be seen in the graph shown below.



Use a 450:50 transformer with no center tap on the 450 Ohm winding in order to help cancel common mode noise carried on coax.

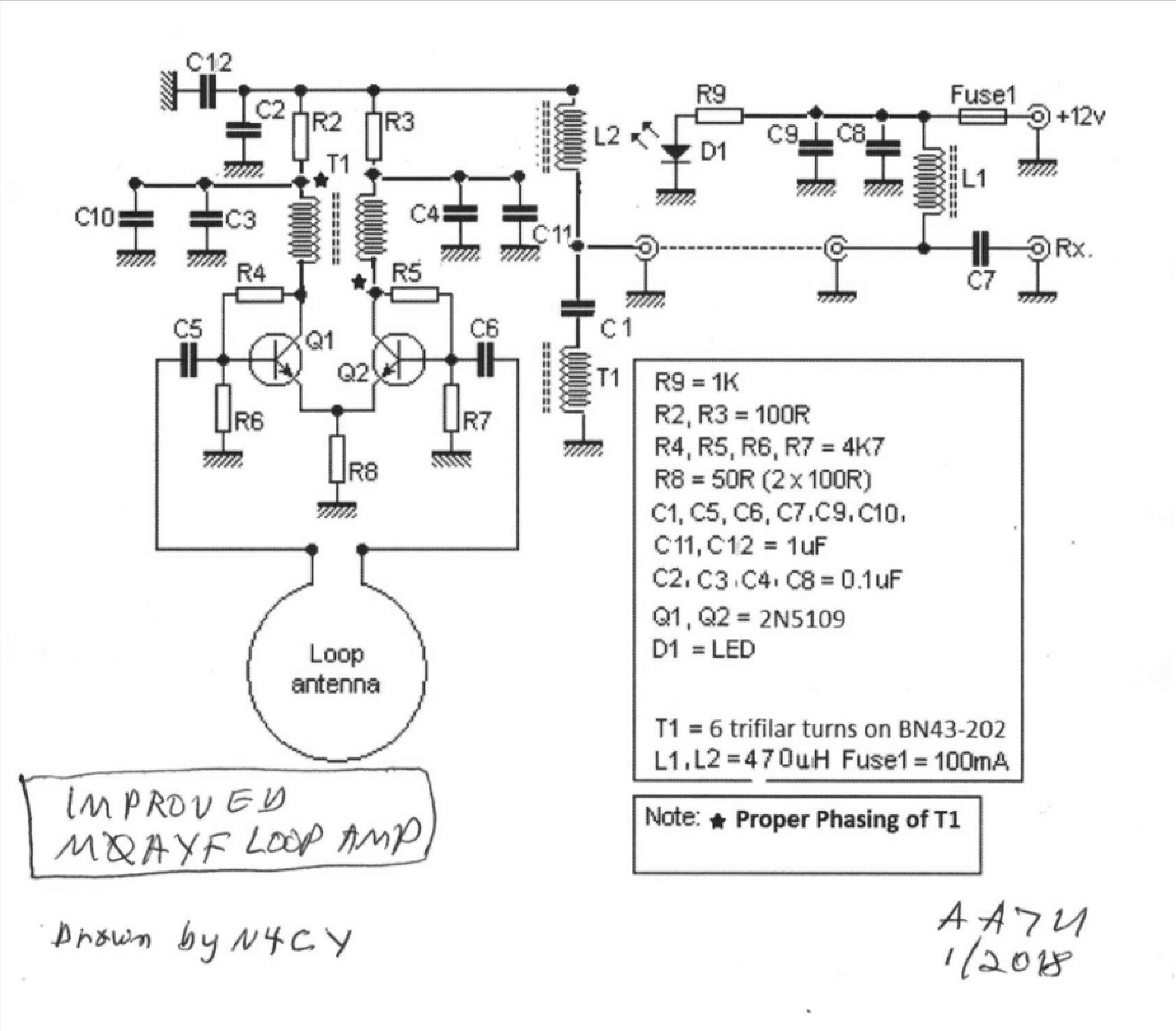
It is essential to maximise common mode noise rejection by choking the coax feed cable.

Amplifier

I originally used a variant of a simple design from G8CQX https://www.qsl.net/m0ayf/active-loop-receiving-antenna.html that has been updated by M0AYF

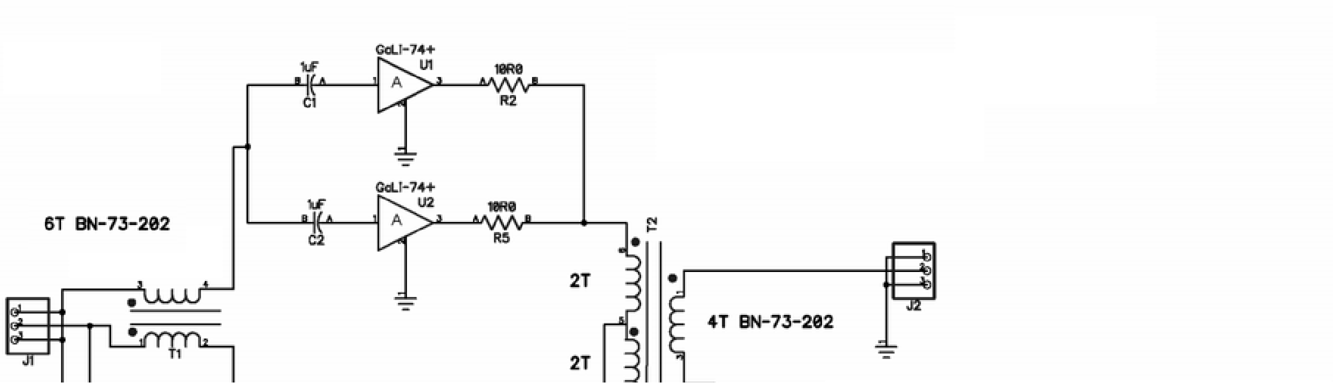
However I would not reccomend this design as the thrird order IMD performance is quite poor.

OIP2 Two Tone +75 dBm
OIP3 Two Tone +27 dBm



I now use a version of an obsolete Clifton Labs design which uses four push pull pairs of GALI-74 MMIC's.

https://www.okdxf.eu/files/Z10046A%20Manual.pdf



The circuit works well, and I've modified the input with a 12:4 ratio transformer on a BN73-202 binocular core, which gives an input Z of 450 ohms and nice flat response from a few KHz to 30+ MHz with a SWR of <1.6:1.

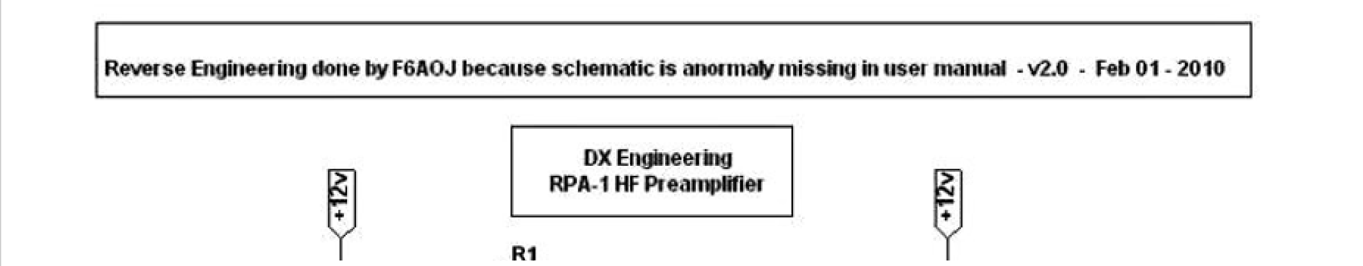
With 80mA bias per device the IMD performance is very good.

OIP2 Two Tone +87 dBm
OIP3 Two Tone +43 dBm

The only downside is that it draws 350mA, which makes feeding power via bias tees quite difficult.

Update - although the above circuit works well, the GALI-74's are very susceptible to damage when connected to a large loop.

For this reason I'm now using a DXE RPA-1 clone, modified with a 7:2:2 turn input transformer wound on a BN73-202 core.



Summary

A 30ft (10m) per side square loop provides the best results from 1.8-30MHz

Feed point should be 1/2 way along one side

Loop should ideally be mounted 0.1 to 0.5m above ground for best results at frequencies > 10MHz

Loop laid directly on ground works OK and may even work to a depth of a few inches under the surface, but attenuation on the higher frequencies is likely to increase

A 10 to 20dB pre-amp is required to bring signal levels up to more typical values

An amplifier with good IMD performance is required and should have a flat frequency response and a 450 Ohm input impedance

Thicker wire may help reduce loop inductance and minimise unwanted impedance excursions.

Orientate loop to minimise interference from local noise sources.