The ON7WP Magnum: a lenght efficient high power vertical antenna using non-resonant traps.

Multiband trap antennas are popular on HF. The W3DZZ is a dual band antenna for 80-40m that is used by many hams around the world. Unfortunately the design is only using part of the antenna on 40m and the traps are prone to arcing with high power. The trick is to use center loading with non-resonant traps…

*Very little is found on the web about this amazing type of non-resonant trap antennas. Very few commercial designs use the principle as well (Butternut verticals). The **W8NX** (SK) publication in QEX march-April 2004 describes in detail this concept, calling this the "dominant element" principle. W8NX did a lot of work on these antennas.*

*This article describes the design, construction and tuning of **a dual band vertical antenna for 160 and 80** meter but it can be scaled to any other two bands using the same formula. Previously I designed a similar horizontal dipole antennas for 80-40m and 160-80m.*

Design:

Determine the two wanted center frequencies, in my case 1,875 and 3,800 MHz. Calculate the mean arithmetic frequency as the square root of the product of both frequencies.

SQR(1,875 x 3,8)=2,67 MHz

This will be the trap frequency. It is not a real "trap", at the lowest frequency the coil will be dominant, at the highest frequency the capacitor will be dominant.

Now for a resonant circuit on 2,67 MHz we want XL at 1,875 MHz = Xc at 3,7 MHz. We look for a coil that resonates our antenna on the lowest frequency with a capacitor matching the high frequency. This value XL or Xc of 385 ohm (best approach for this dual band type) we put in our EZNEC drawing, as a center load of the dipole. We design the full antenna length also approximately to this frequency taking into account the shortening factor of around 95% due to using insulated copper wire.

I made a small excel tool to calculate the values:

Trap calculator dual band antenna

Zload	385	(Ohms)
F1	3,8	
Freq(M)	2,669269563	(MHz)
F2	1,875	
L	22,95558828	(uH)
C	154,8698821	(pF)
Length	26,69269563	(m)

So we end up with a 28m total length and a center coil of 23 uH. In order to resonate the antenna at 3,7 MHz we need a (high voltage) capacitor of 135 pF we place in parallel with the coil.

Loads (RLC)

Load Edit Other

	Loads										
	No.	Specified Pos.		Actual Pos.		R	L	C	R Freq	Config	Ext Conn
		Wire #	% From E1	% From E1	Seg	(ohms)	(uH)	(pF)	(MHz)		
▶	1	1	50	50	6	1	23	135	1,875	Trap	Ser
*											

Construction:

Antenna wire is preferably 6 mm2 stranded tinned wire, the type used to connect solar panels. This solar wire is very rugged and protected against UV, while having very low Ohmic loss. We need 2 equal lengths of 14 meter.

At the bottom we put a current balun, something like 10 turns of preferably Teflon coax over a T240-31 core.

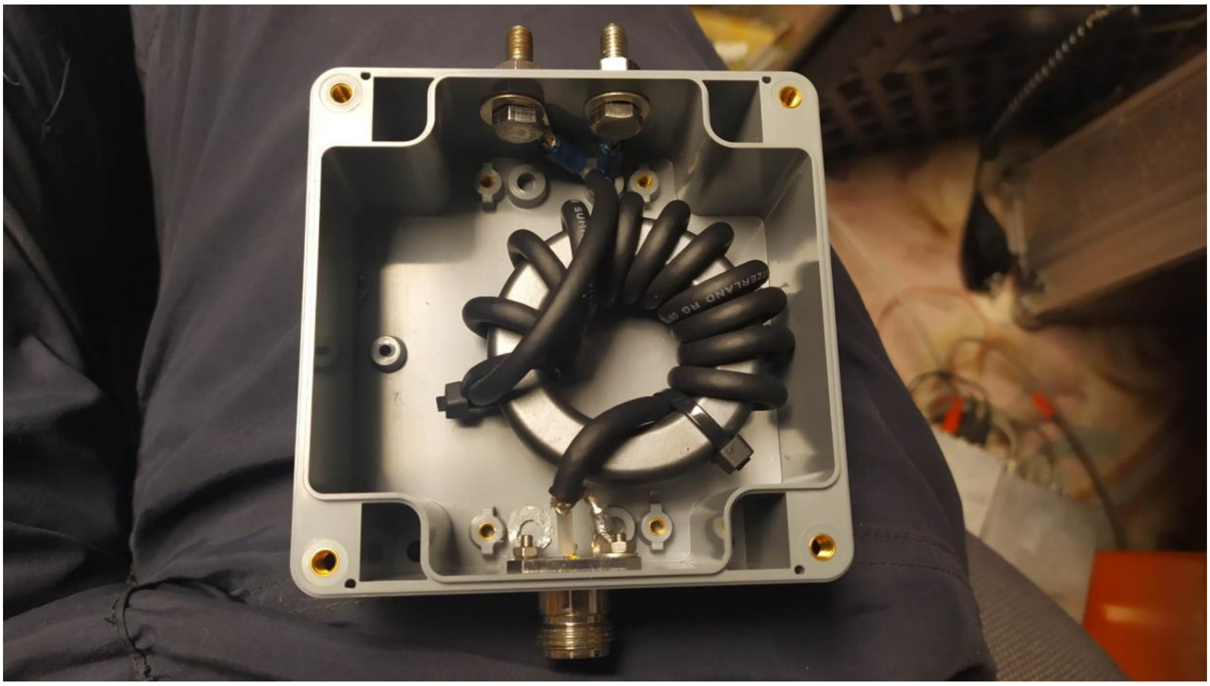


Figure 1: Current balun using regular RG58.

The trap we built on PVC tubing of 40 mm. 33 turns of 2mm CU transformer wire on (white) 40 mm PVC tubing (gray tends to hold carbon).

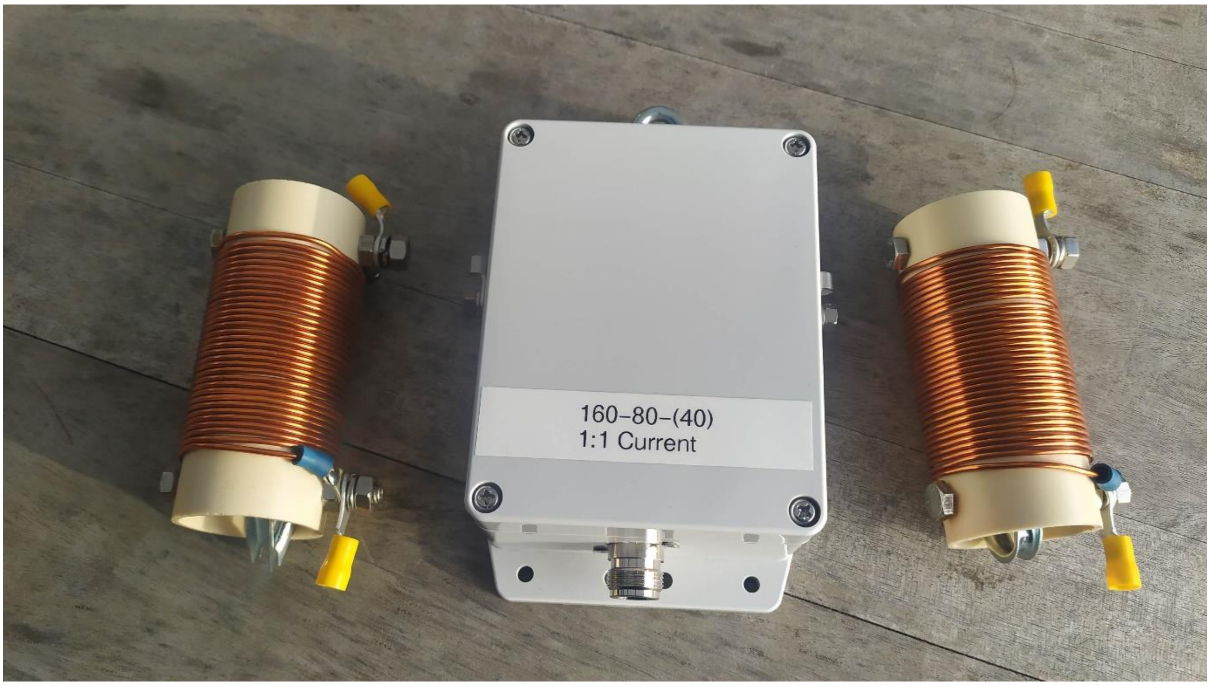


Figure 2: similar 23uH coils and a current balun as used as well in the dual band dipole design

The capacitor is made out of RG58U coax. Start with 1,7 meter or 170 pF in parallel with the coil. The coax capacitor is not yet installed on the picture below but runs in parallel with the wire facing the balun. Mass connected to the inside, center core to the outside of the trap.

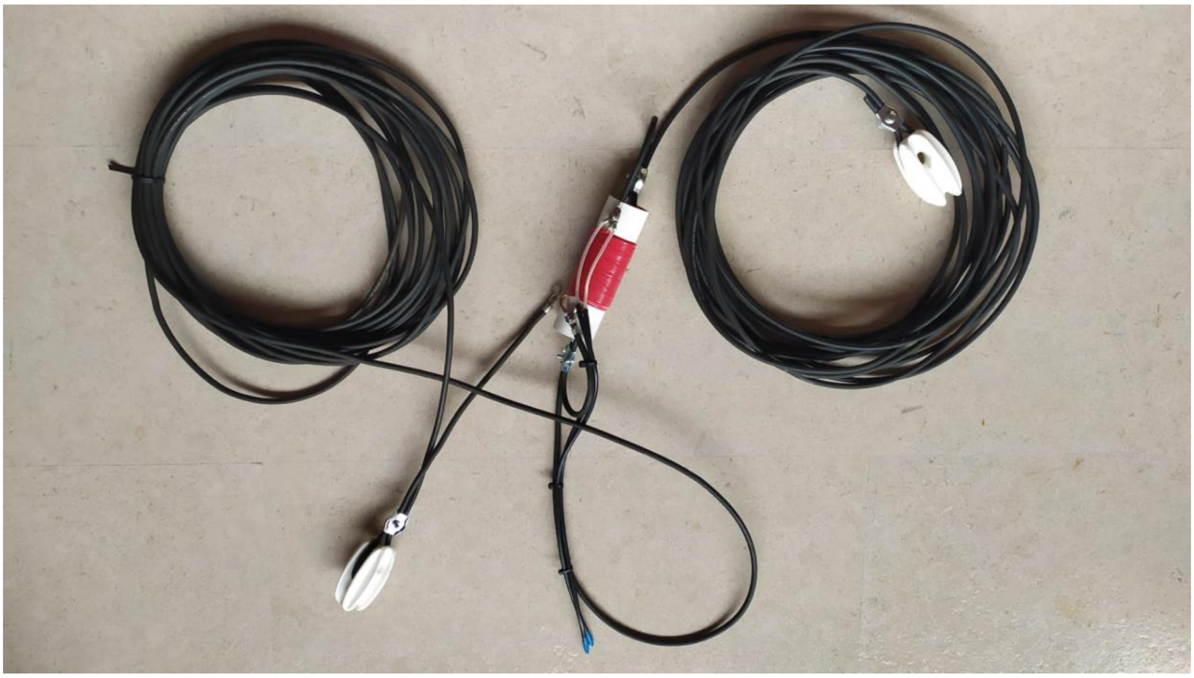


Figure 3: a picture of a dual band vertical using the non-resonant trap principle. The tuning capacitor is mounted in parallel with the wire side coming from the balun, grounded at that side so there is no extra inter-wire capacity. To decrease length I used two pieces in parallel. Ends are slightly stripped and insulated (blue tape) to prevent arcing in rainy weather.

Optimum coil dimensions:

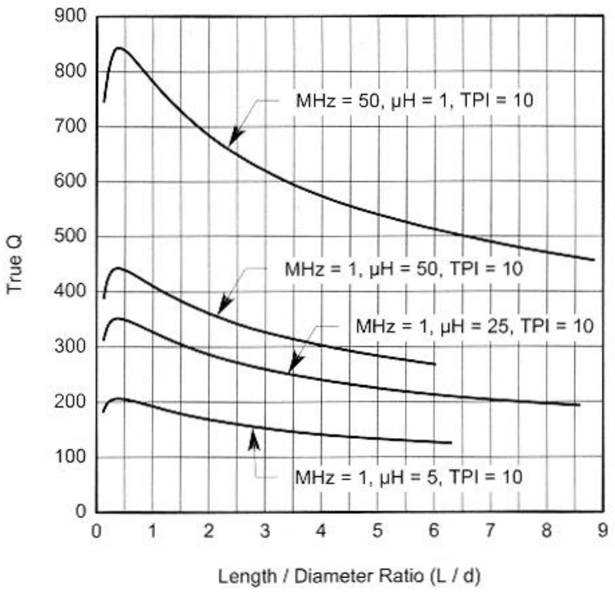


Figure 4: Q factor depending on coil former. L/D is about 2 using 1,7 mm enamelled Cu wire on a 40 mm PVC tubing. But Q factor is not a real issue here as we operate out of resonance.

Tuning:

Connect a suitable **counterpoise**. I used the garden fences of my plot and the neighbors connected together. These are very efficient elevated radials. Several studies have proven 4 elevated radials to be as efficient if not better than 120 buried ones. If you have room use 4 wires of 20-40 meters 30 cm above ground.

(A similar antenna I built for 80-40m used the mounting frame of my roof mounted solar panels as counterpoise, also working very well.)

Start by the lowest frequency. Shorten the end of the coax tuning capacitors until you reach your design goal. 2 x 14 meter and 170 pF should put you somewhere around 1,800 MHz. Cut the 170 pF coax capacitor until you are where you want to be.

Tuning to 1,875 MHz should give you like 100 kHz bandwidth between 3:1 SWR, something your rig built in tuner can easily handle.

Then go to the 80 meter design frequency and check for resonance. SWR should stay below 3:1 from 3,60 till 3,80 MHz so 200 kHz bandwidth. These two bands should be aligned. Cutting the capacitor slowly moves down the 160m frequency while more drastically lowering 80m resonance.

By using a slightly bigger coil like 24 uH you can get the 80m resonance higher while keeping the lower dip if you fancy the DX window.

Less capacitance increases the split between both bands, but also raises both resonance frequencies. Increasing the coil or antenna length lowers both bands. But beware this is a complex iterative process. Given values should be fine.

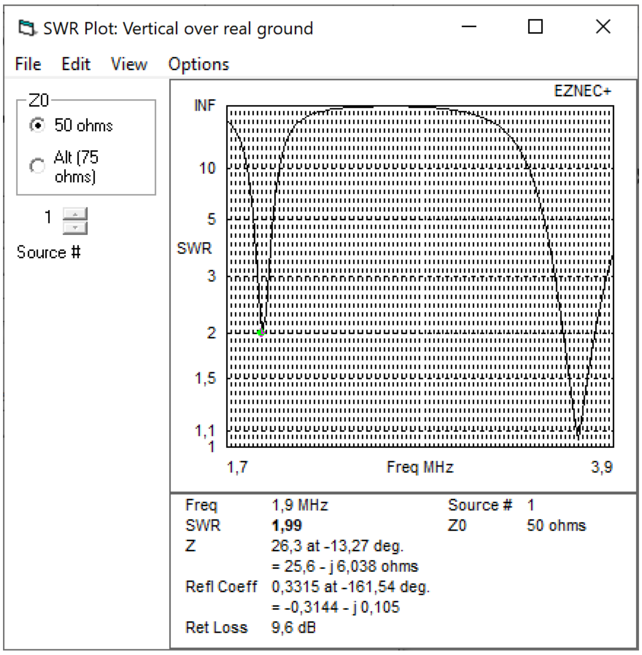


Figure 5: combined VSWR plot

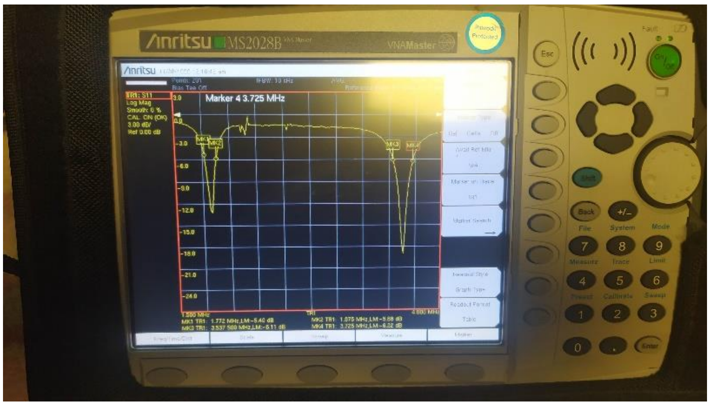


Figure 6: measured Return Loss (on a similar principle operating dipole)

Performance:

Let’s take a look at the elevation patterns, most important for analysing the performance. This is of course an omnidirectional antenna. Mounting it slanted pulled up towards a tower creates a slight gain into the direction where the antenna is sloping, whilst keeping almost zero upwards radiation.

Left side graphs show the ON7WP Magnum, right side is a full size quarter wave both over real ground. Performance is only down by 0,33 dB on 160m and 0,15 dB on 80m. Elevation pattern is even better for the Magnum on 80 meter due to the slightly longer length.

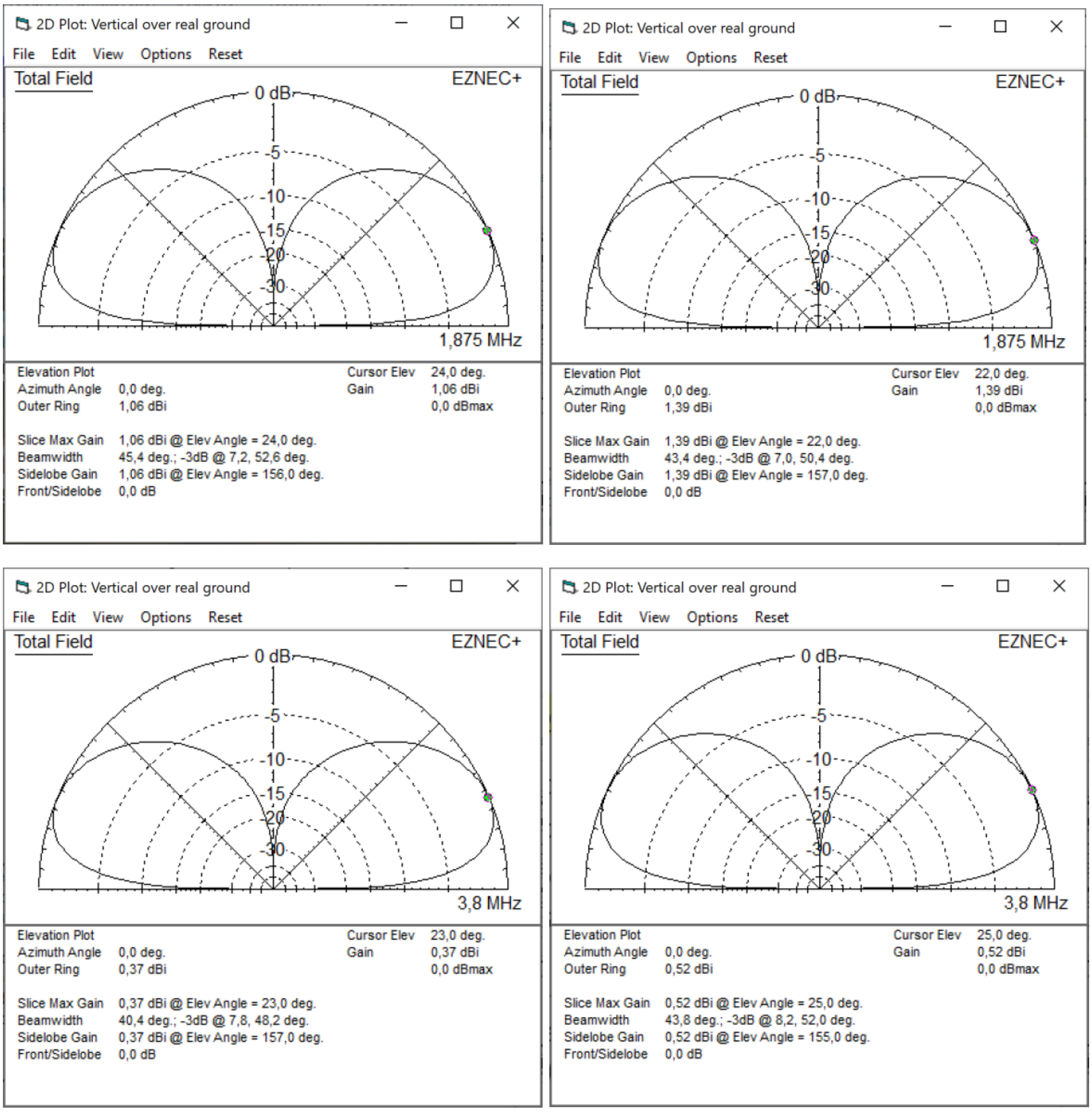


Figure 7: elevation plots compared to a full size quarter wave vertical (Right)

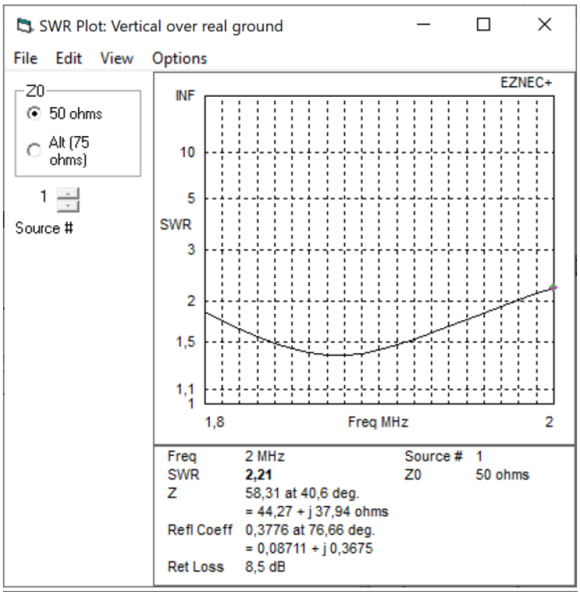
A typical DX omni antenna as you can see from these plots with low elevation angle on both bands.

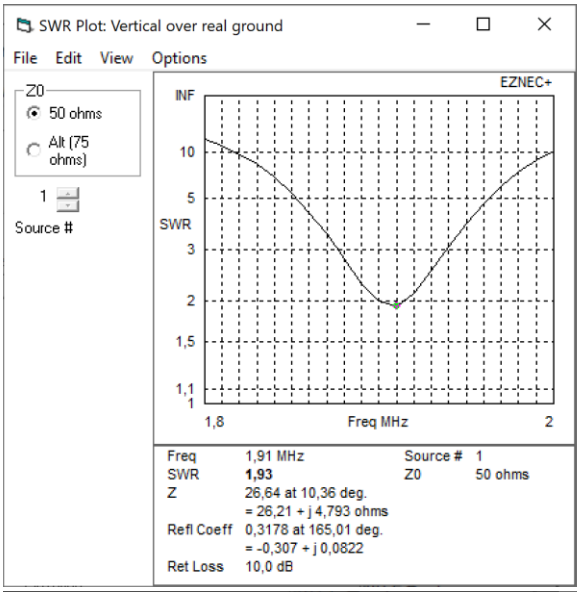
This antenna is NOT suited for NVIS (local) communications lacking upward radiation.

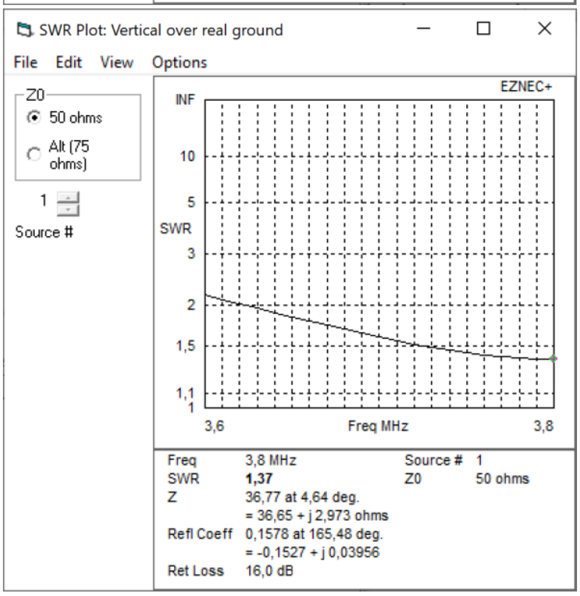
Antenna matching:

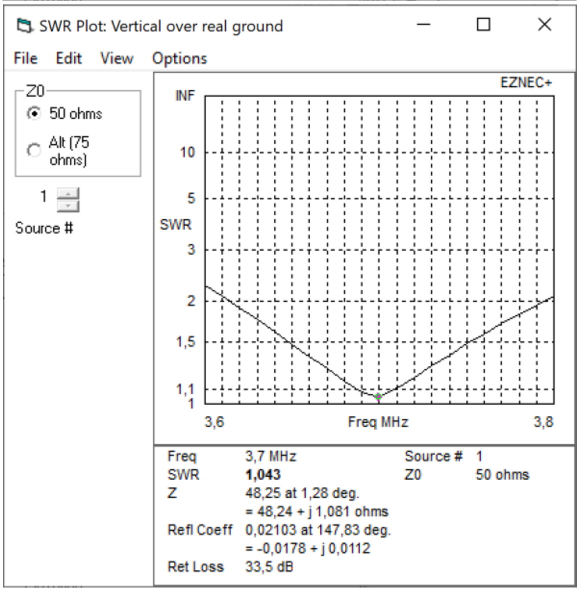
With the current coil of 23 uH and the coax tuned to 1875 kHz the antenna covers the full 80m phone band with very good matching around the middle at 3700 kHz. Matching on 80m is even far better than a standard full size quarter wave. On 160m we get around 100 kHz bandwidth but the antenna can be used flawlessly between the 3:1 VSWR limits with the internal tuner of most transceivers or linear amplifiers.

Increasing the coil a bit and decreasing the capacitor value the 80m dip could be moved up to the 3780-3800 segment for those only interested in the DX segments.









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