M3KXZ 'no counterpoise' antenna

I recently came across a ‘No-Counterpoise’ antenna described by designed by Peter Millis M3KXZ and based on an original design by K9ESE.

Details of the antenna can be found here http://www.outsideshack.com/page2.html

I was impressed by EZNEC models included on the site, and analysis that had been performed by L.B.Cebik http://www.cebik.com/content/a10/wire/m3kxz.html (free login required to view)

Before constructing the antenna I ran the EZNEC files and found them to be reasonably accurate, except in one major area, which is the modelling of closely spaced conductors. This is a known problem and is usually worked around by choosing a minimum spacing of about 1” (25mm) and ensuring that all segments of parallel conductors are aligned with each other.

However alarm bells started ringing when I saw that the actual antenna had been made from ‘zip cord’ a light weight 2amp rated figure of eight mains cable, which is commonly used to connect speakers to audio amplifiers. I know from experience with other antennas such as Zepps and J poles that ‘zip cord’ do not work particularly well in any of these applications.

There are three main problems associated with ‘zip cord’ when used for antennas. The first is the low characteristic impedance which is around 100 ohms, the second is the dielectric loss in the insulating material, and the third is the very close coupling between the two conductors, which make them appear more like a single wire when used as a radiating element.

As a test I made up one of the 25ft versions of the ‘zip cord’ antennas and used a 10m fishing pole to support it. The antenna was matched to the transceiver by use of a CG-3000 auto-atu at the base feeding the ‘zip cord’ via a 1:1 air cored balun which was optimised to give good choking performance over the 10 to 30MHz frequency range.

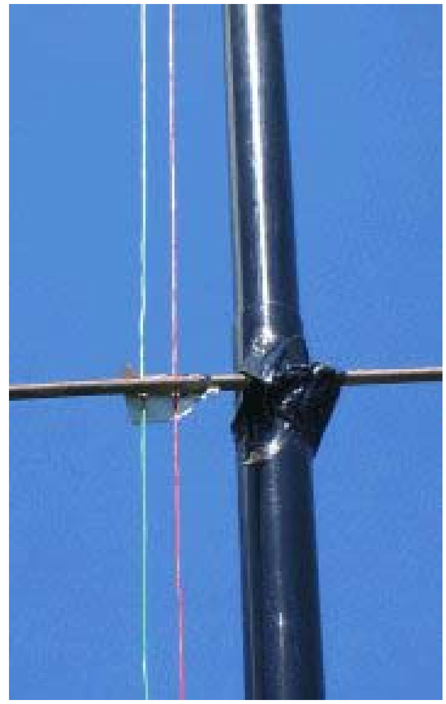
Unfortunately, although it had a very flat VSWR curve over the required frequency range it did not radiate particularly well.

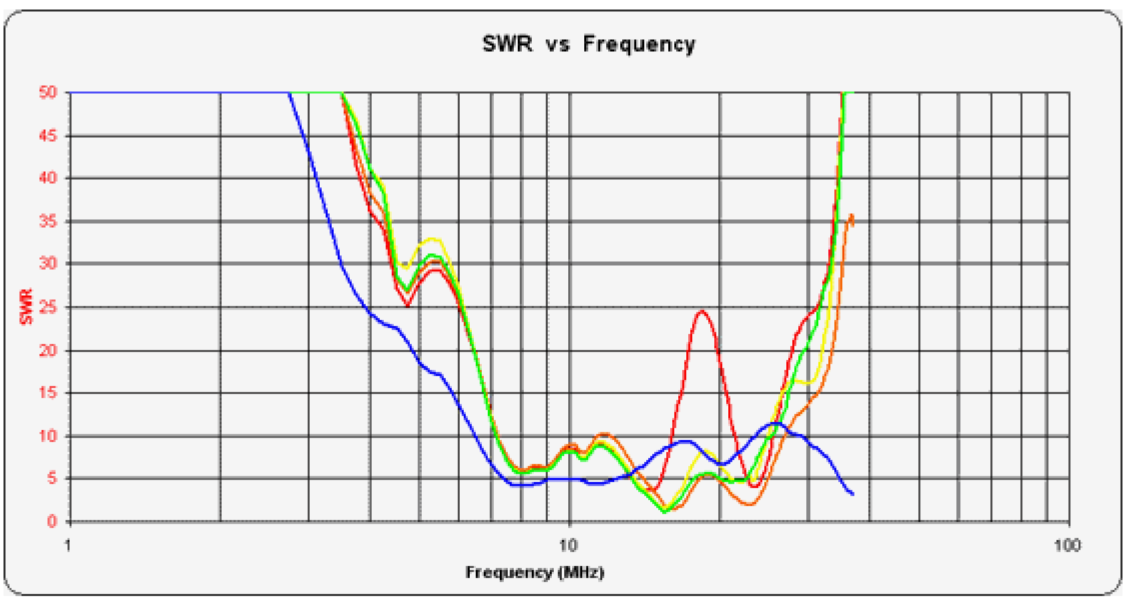
As the M3KXZ antenna is similar to an End fed Zepp I decided that the conductor spacing of the matching section was major factor in the design of this antenna.

This is because J poles and End fed Zepp antennas require a specific characteristic impedance of ¼ balanced line section in order to transform the 50 ohm feed point impedance up to 3 to 4 K Ohm at the base of the ½ wave radiating section.

In order to do this I taped some horizontal garden poles at regular intervals to the 10m mast and then taped the vertical wires to the poles. By varying the position of one of the conductors I was able to try a variety of spacing's between the two wires.

I measured the feed impedance for each spacing. A graph showing the measured VSWR with a variety of spacing's can be seen below.

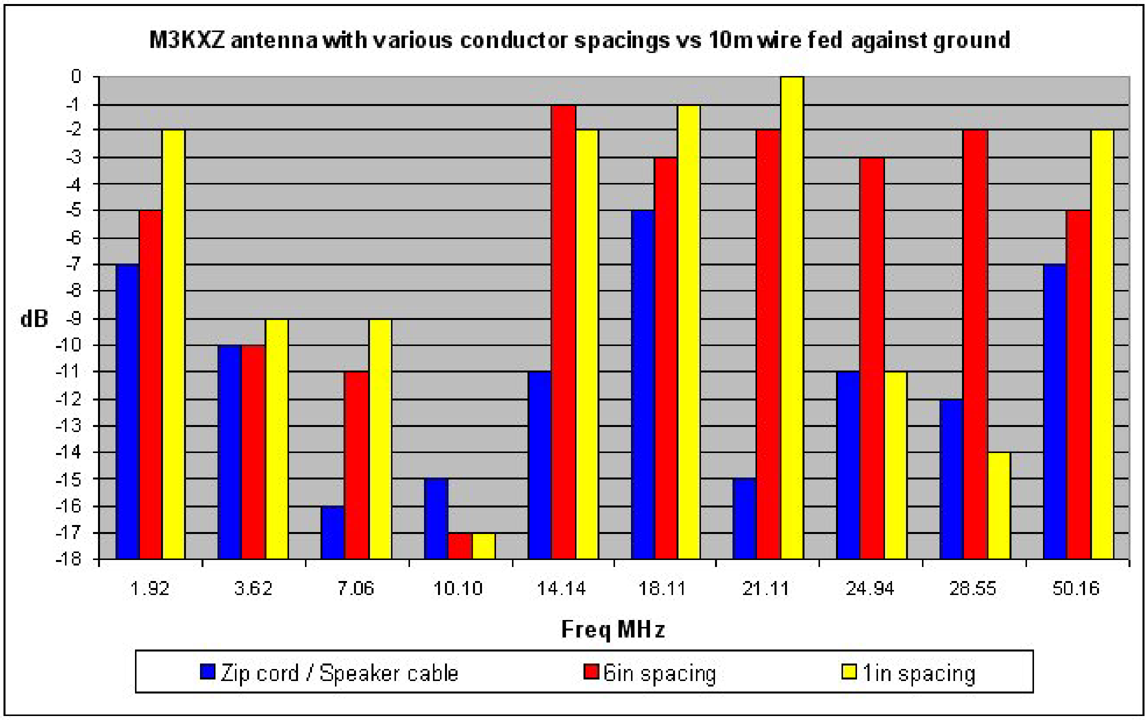




Blue trace – 'Zip cord'
Green trace – 0.5" spacing
Yellow trace – 1" spacing
Orange trace – 3" spacing
Red trace – 4" and greater spacing

All parameters are measured directly at the base of the antenna using an AIM 4170B with no balun connected.

In addition to this I also used the antenna to transmit on each of the Amateur bands between 1.9MHz and 50MHz. I measured the received field strength with a remote controlled Icom PCR-1000 receiver connected to a Datong active antenna. This was located on a building roof approx 20m AGL at approx 2 miles away from the transmit site. The following graph shows the received signal level of the two versions, in comparison to a transmit reference antenna, consisting of a single 10m wire fed against 16 buried radials and supported by the same fishing pole and matched using the same auto-atu as the no-counterpoise antenna.



As can be seen from the graph the wider spacing's give much improved performance.

Generally speaking the wider the spacing the greater the gain; however this is a trade against VSWR at the feed point. A spacing of about 1" (25mm) to 2" (50mm) would seem to be optimum. I found it quite difficult to maintain constant wire spacing, even in a light breeze so for a practical design I would suggest using 450 ohm ladder line in place of air spaced conductors.

However the main conclusion that can be drawn from the above graph is that all versions of the 'no counterpoise' antenna gave a lower measured field strength than the reference antenna which was a 10m long vertical wire, fed against 10 random length buried radials and matched with the same auto-tuner that was used for the 'no counterpoise' antenna.

This discovery made me take another look at the design of J Pole and End fed Zepp antennas. Some very useful information can be found at these websites

http://www.aa5tb.com/efha.html

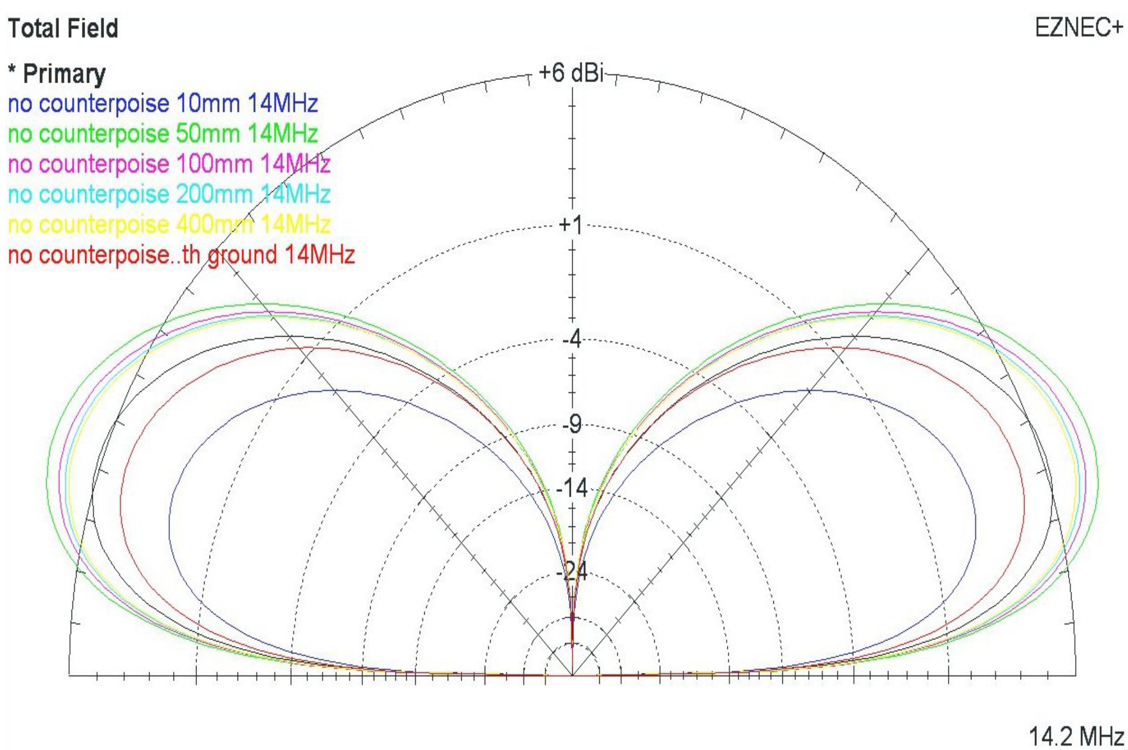
http://www.w8ji.com/end-fed_vertical_j-pole_and_horizontal_zepp.htm

http://www.qsl.net/oe3mzc/hlfewve.htm

From this I concluded that common mode current in the feed line is a major problem. The EZNEC models are not valid because they show the antenna being fed from a perfectly isolated source, and are not able to accurately replicate closely spaced conductors such as zip cord. When testing the antenna I had made a lot of effort to try and isolate the antenna and auto-atu from ground by using a series of air-spaced and ferrite core 1:1 choking baluns. However even with these precautions it is no possible to completely eradicate the influence of common mode currents.

I decided to try modifying the EZNEC model by adding a further wire connected to the base of the balanced matching section. The wire was connected to the bottom end of the shortest vertical wire and the length varied by a few tens of mm.

The graph shown below indicates the differences in gain with only very short lengths of wire connected.



The results are highly suspect, as only a few mm differences in wire length make a large difference in gain approx +/- 3dB.

Either the model is flawed or the antenna requires a very precise configuration to balance current flow in order to optimise the gain. This may be the case as during my receive field strength tests I found it very difficult to maintain consistent results between runs, as moving connecting cables seemed to influence the performance. I did not notice this when measuring the 10m vertical wire using the same support pole and location. I obtained the same values within about a dB of each other at the end of the measurement session, when I re-ran the tests on the vertical wire as a confidence test.

Further work is required on this antenna, my suggestions include

- Varying the length of the longer radiating element to optimise the match over the required operating range. The current antenna design is like an end fed Zepp but with a 1/4 wave element in place of the Zepps ½ wave element. It may be possible to find another length of wire somewhere between the two where the match and gain are optimised as the antenna would then be more like an offset fed vertical dipole.

- Varying the taper of the balanced matching section at various points to see if a wider operating bandwidth can be obtained.

- Connection of various baluns, counterpoises, radials and earth rods to try and minimise common mode current in the connecting feeder.

- Tuned lengths of coax feeder to optimise the match at the transmitter without the requirement for an external ATU.