A Dual 160 m and 80 m Vertical with Simple Matching

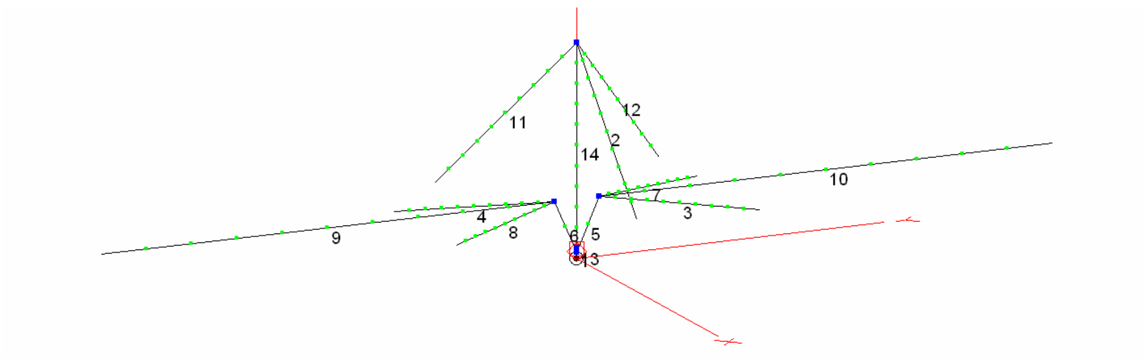
Background
My old 80 m inverted L, described briefly in another note, proved to be a substantial success in the mission to kill off 80 m DXCC in one season. It was 14 meters of telescoped Al tubing up with a (somewhat sloping) top wire of 16.7 m and 6X 2.5m high elevated radials [see R. Severns article, March 2010 QST for motivation] of 17.4 m length. The inductive reactance from the intentional excess length beyond an electrical quarter wave was tuned out with a series capacitor leaving a resistance near 50 ohms for a reasonable match over much of 80 m, but the series capacitor [see ARRL Antenna Handbook, 21st edition, p6-41 for example] did need to be manually retuned between cw and phone segments. The SWR was low enough that no additional matching is needed, which is good since I don't have (or want) another box to tune. In desperate times, this antenna could be used on 160 if the top wire was extended a lot (and low), but it was poor on that band.

Since the 80 m DX needs were mostly taken care of, I looked around for a relatively simple way to move to 160 for DXCC there, while retaining a reasonable 80 m capability. When I told the XYL that I was planning a 160 meters antenna, she correctly pointed out that that is a lot of meters. A 40 m high vertical with many 10's of radials of comparable length would be nice but that is a big deal.

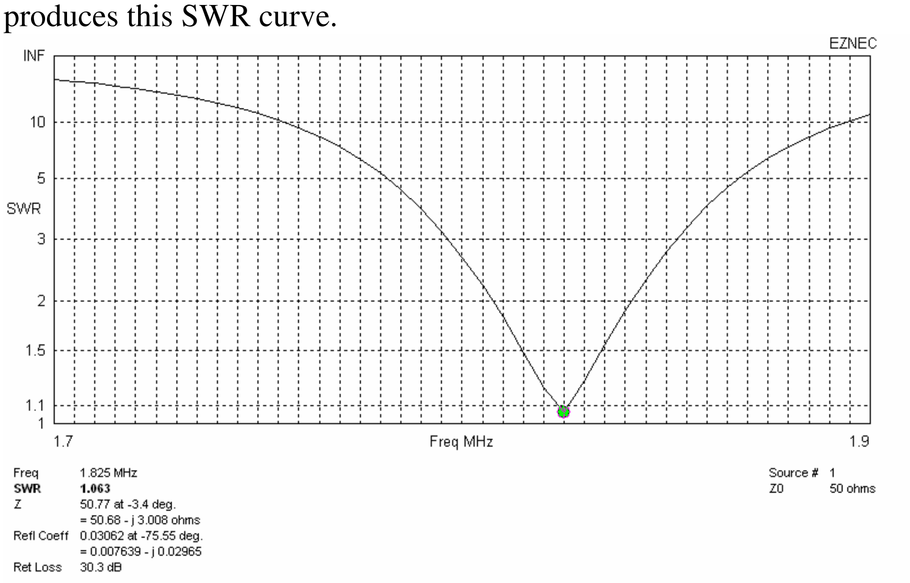
I settled on making the original 80m vertical section somewhat higher, and adding 3X conducting guy wires at the top for loading, by extending the existing 80 m antenna vertical section with two additional 6' lengths of tubing. The guys can provide significant top loading as well as very much needed support. Being cheap and having some smaller tubing on hand, I chose a non-telescoping connection (and mechanically weaker) lineup. Now the sequence goes 2 inch OD going down to 1.125 inch for the first 8, then 3/4" and 5/8" OD sections topped by a 3' ½" OD stinger for about 17.5 meters total. With existing junkbox hardware, this was a practical maximum to the height. With the height largely fixed, the available tuning parameters become the lengths of the top guys and the radials. The impedances at both 160 and 80 are relatively insensitive to the (now 4X) 80 m radial lengths. However the 2X 160 m radial length does have noticeable impact on 160.

As with the old antenna, for 80 m the electrical length is to be > $\lambda/4$ but not so much that the resistive component of the raw impedance is substantially greater than 50 ohms (for example as much as ~100 ohms is tunable to full power with the AL-811H amp output circuit). This limits the lengths of the top guys. For 160 m the electrical length will be < $\lambda/4$ and the resistive component of the raw impedance is expected to be much less than 50 ohms. Longer top guys will raise the resistance but a compromise with 160 vs 80 operation is needed for the guy length.

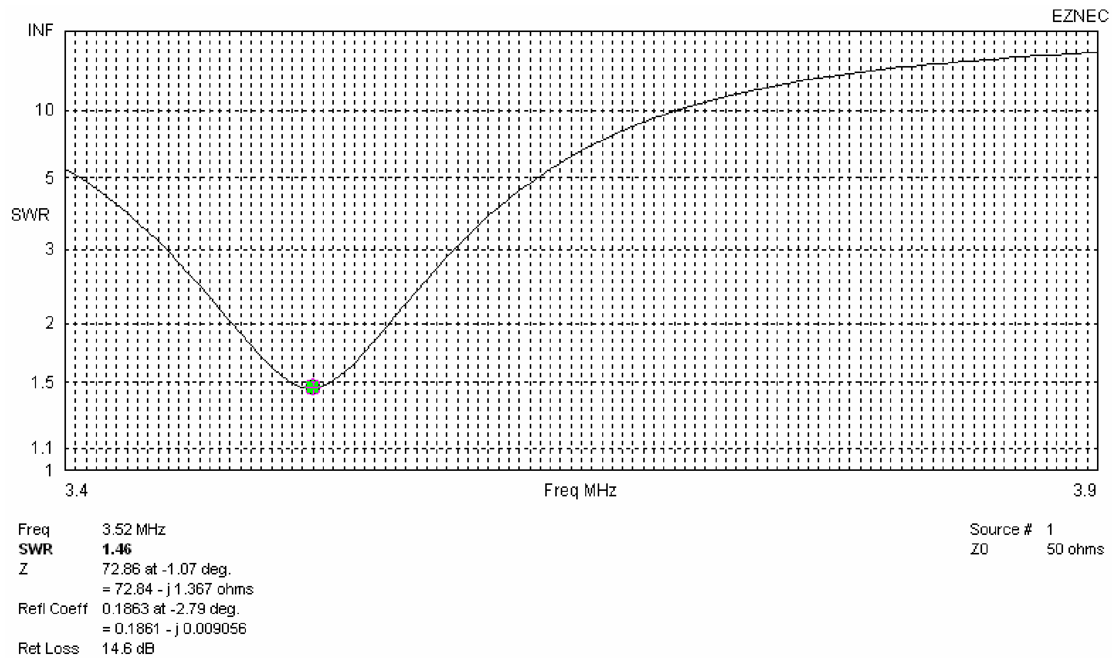
So time to break out EZNEC to get detailed starting lengths with the objective of making the 160 m short to be matched with a simple inductive short "hairpin" match and make the 80 m part be long so to be matched with the old series capacitor. The nominal plan is to take 2 of the old 6 raised 80 m radials and raise them to ~5 meters and lengthen them to provide 2X 160 m elevated radials and 4X 80 m ones. Much computation with variation of possible lengths was done together with an eye on potential hairpin matches, which work with only a limited range of raw input impedances, for 160 m. Of course, this is just to provide a starting point for cut and try adjustments. It turns out that the absolute impedances predicted by EZNEC are not terribly close to those found (due to unknown ground properties?) but the model impedance changes with small length changes are pretty good so it is a tool to aid the cut and try.



For this example the bottom of the vertical is 0.5 m off ground, 17.5m long and has three 16.6m top guys.   The160 radials are 44.9 m long and the 80 m radials are 17.8 m. An extra 5 ohm load is added in series to simulate expected ground losses. On 160 a 25 ohm inductance is added in shunt across the feed as a hairpin match. The model impedance on 160 without the hairpin is Z=9-j20 including the added 5 ohms. Adding the hairpin shunt produces this SWR curve.



For 80 m the needed load is a series C with Xc=-550 ohms (without the hairpin) but with all lengths the same. This results in the next SWR plot.



Here the model resistance at 3.525 is 73 ohms (still including the nominal 5 ohm added ground loss). At 3.8 MHz it is 132 + j366. Obviously the 366 ohms inductive can be tuned out with a smaller series C and then the SWR will have a minimum of 2.6 at 3.8 MHz.

This was deemed to be a good starting point for final adjustments to the dual band antenna. And there was much fiddling and MFJ measuring.

When all was said and done the vertical portion remained at 17.5m long and top guys became 17.2m, the 2X 160 radials became 39.9 m (rather shorter than the model) and the 4X remaining 80 radials are 17 m, unchanged from the old inverted L.

The raw (with no loads) impedance at 1.825 MHz was ~ 8-j12 which can be pretty well matched with a “hairpin” inductance coil (~1.7 microHenry) of about XL of +j18 ohms shunted across the input. Of course the MFJ does not reveal the sign of the reactance so some comparison with the model (or insertion of extra cable for measurements) is needed to find out. The resulting SWR curve is similar to that from the model. Getting an input complex impedance that allows a hairpin match to work well (transform the impedance to 50 ohms resistive) required substantial fiddling with the 160 m radial and top loading wire lengths to fit with the limited raw impedance range of hairpin matching. This was again guided by the effects of small changes to the model.

The raw impedance on 80 m (measured at the base) is big enough that the MFJ bulks but tuning the series variable capacitor (25-500 pfd here) to ~ ¼ inch plate overlap (~ -j600 ohms at 3.525 MHz) removes the expected large inductive part of the raw impedance leaving Rant = ~ 100 ohms resistive at 3.525. At 3.7 and 3.8 MHz the (different) capacitor settings make the impedance resistive but at values of ~250 and ~500 ohms respectively, or so says the MFJ. This rise with frequency is substantially faster than the

EZNEC model predicts and makes the antenna problematic at best for 75 meters. However it is decent on 80 m CW where the amp is willing to provide full power and seems to put out a respectable signal judging by the required pile up cracking times. One might be able to add a 4:1 unun, on 80 m only, to improve 80 m matching over the band. The EZNEC model suggests that ~ 50% increase in 80 m radial length will improve (i.e., lower) the impedance on 80 with little effect on 160. This accuracy of this claim has not been tested.

Of course, if you are willing to have a flexible high power remote matching network at the base of the antenna, it is possible to get a SWR near 1:1 at any desired frequency if the antenna dimensions are anywhere within reason, and a good signal should ensue. However such networks are expensive and add a complexity that is good to avoid. Besides, my mission was to make an antenna that could be matched by simple means and using materials on hand, if possible

Mechanical Matters

The base consists of a 5' upright length of 2X6 stuck in a concrete filled hole. The lowest 2" tube section is then held in place against the 2X6 by a 2' length of PVC pipe with an ID of about 2" by using two U bolts. This pipe ID is just a little short of 2" so it was slit with one cut lengthwise giving a very nice fit when compressed. This holds the antenna in place very well and, of course, the pipe is an insulator. A platform on the lower portion of the 2X6 holds the matching network.

The elevated radials are supported by concrete bound 8'X2" round landscaping poles with 2X2 extensions.

The vertical is guyed with 3 lengths of dacron rope at two levels (at ~10m and 13.5m) in addition to the top guys at 17.5m. The wise should consider using at least 4 guys at each level. The 3 guys per level are okay most of the time but when the wind direction is close to being in the direction of a guy in the upwind side of the antenna things, support is not so good, but it is exciting. The original guying set up had just one set of rope guys placed at ~10m (barely visible in the photo above). A mighty wind demonstrated the folly of that requiring the ordering three new tubes (1 5/8, 1.5 and 1/3/8) since they no longer telescope for much in spite of looking fairly straight. Since the raising strategy is beginning with most of the tubes telescoped together, non-telescoping is not an option.

Even after the new guying line up, another wind bend the smallish two longer upper sections but this was fixed pretty easily by telescoping it down and straightening (mostly) the bend tubes. If it makes it one more season, I'll be content.

Again if you are thinking of trying this at home kids, I suggest you using perhaps 10 telescoping tubes starting with a 2.125" and ending with 1". That would get you to about 16.5 meters of tube requiring somewhat longer loading guys on the top. Using 4 rather than 3 would help there. Probably you could get away with guying at two levels with this tubing.

Performance

On 160 this antenna was run with ~500 watts fairly often during the 2010-2011 season, especially in the contests. Generally it scored fairly early in the pile ups. Starting with 18 countries before the new antenna, a total of 61new countries were worked bringing the summer 2011 grand total to 79. With substantial luck, 160 m DXCC might be reached in one more season, barring a mighty wind.