Some comments on isolation chokes for 160m verticals

A short time back W7WZ asked me about the design of air core coaxial common-mode chokes (or baluns) for isolating the feedline on 160m verticals with elevated radials. At 40m and up that's a pretty easy question to answer: just use enough turns to have an impedance (Xc) of 1-2k Ohms at the operating frequency. Such a coil made with coax is very practical at these frequencies but when you go down to 160m and add the need for high power, a coil with Xc = 2k Ohm can be quite large.

The question then becomes "just how much impedance do I really need"? How small can I make the coil but still get the job done? It turns out that the answers depend on the details of the antenna being used. To explore this I did some NEC modeling and also dragged out a old 160m choke I used in the past. The following is what I found. I would emphasize that this is not intended to be an exhaustive discussion but just a few quick observations.

NEC modeling

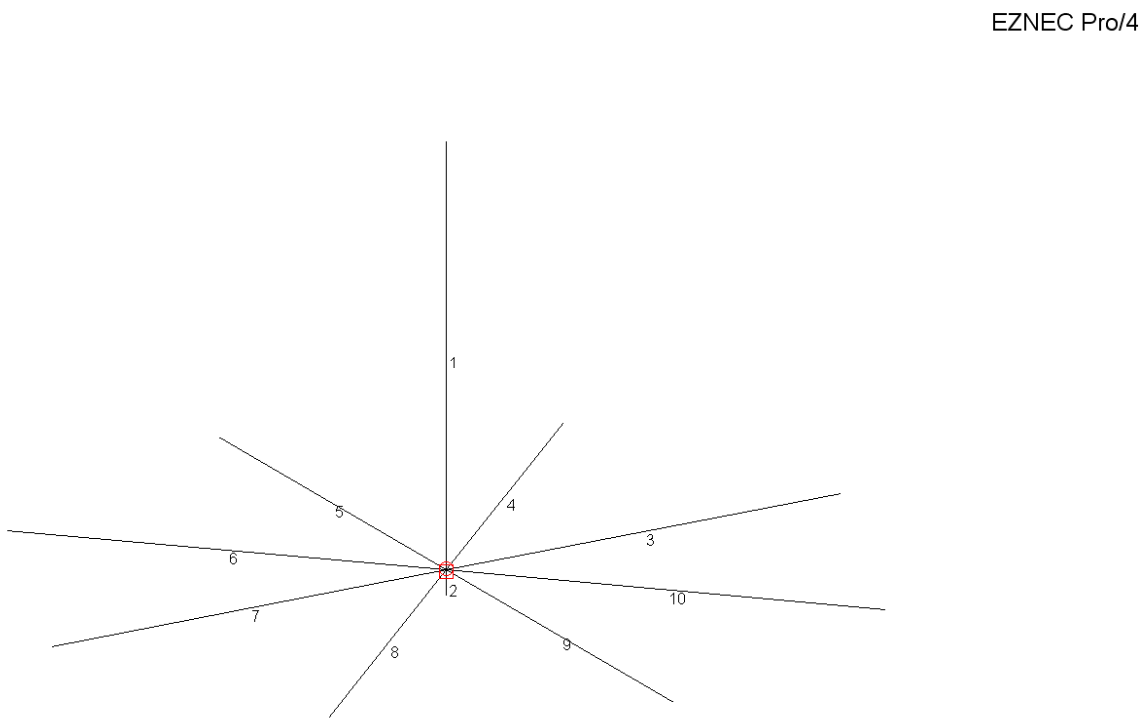

Figure 1 - typical NEC model.

Figure 1 shows the model for the eight radial case. Wire 2 goes from the junction of the radials to ground and has a series inductor (Lc) with impedance Xc. The base of the antenna is located 8' above ground and the test frequency is 1.83 MHz. The antenna was resonated at 1.83 MHz without wire 2 (the wire from the junction of the radials to ground) and with the radial lengths and the vertical length equal. The base current was 1 A. I ran models with 2, 4 and 8 radials using values for Xc ranging from 1 Ohm to 10k Ohm. The modeling results are given in table 1 and graphed in figures 2 and 3.

Table 1 - modeling results

	L=H=133.26		2 radials	L=H=132.97		4 radials	L=H=132.56		8 radials
Xc	**Rin**	**Xs**	**Ic [mA]**	**Rs**	**Xs**	**Ic [mA]**	**Rs**	**Xs**	**Ic [mA]**
1	34.53	-6.09	410	34.80	-3.91	333	35.01	-2.15	251
100	36.49	-1.96	118	36.36	-1.16	100	36.13	-0.67	79
300	36.97	-0.97	49	36.75	-0.48	42	36.44	-0.28	33
500	37.09	-0.72	31	36.86	-0.29	26	36.52	-0.17	21
700	37.15	-0.60	22	36.91	-0.21	19	36.55	-0.12	15
1000	37.19	-0.51	16	36.94	-0.15	14	36.58	-0.09	11
3000	37.26	-0.36	5	37.01	-0.04	5	36.63	-0.02	4
10000	37.29	-0.30	2	37.03	0.00	1	36.65	0.00	1

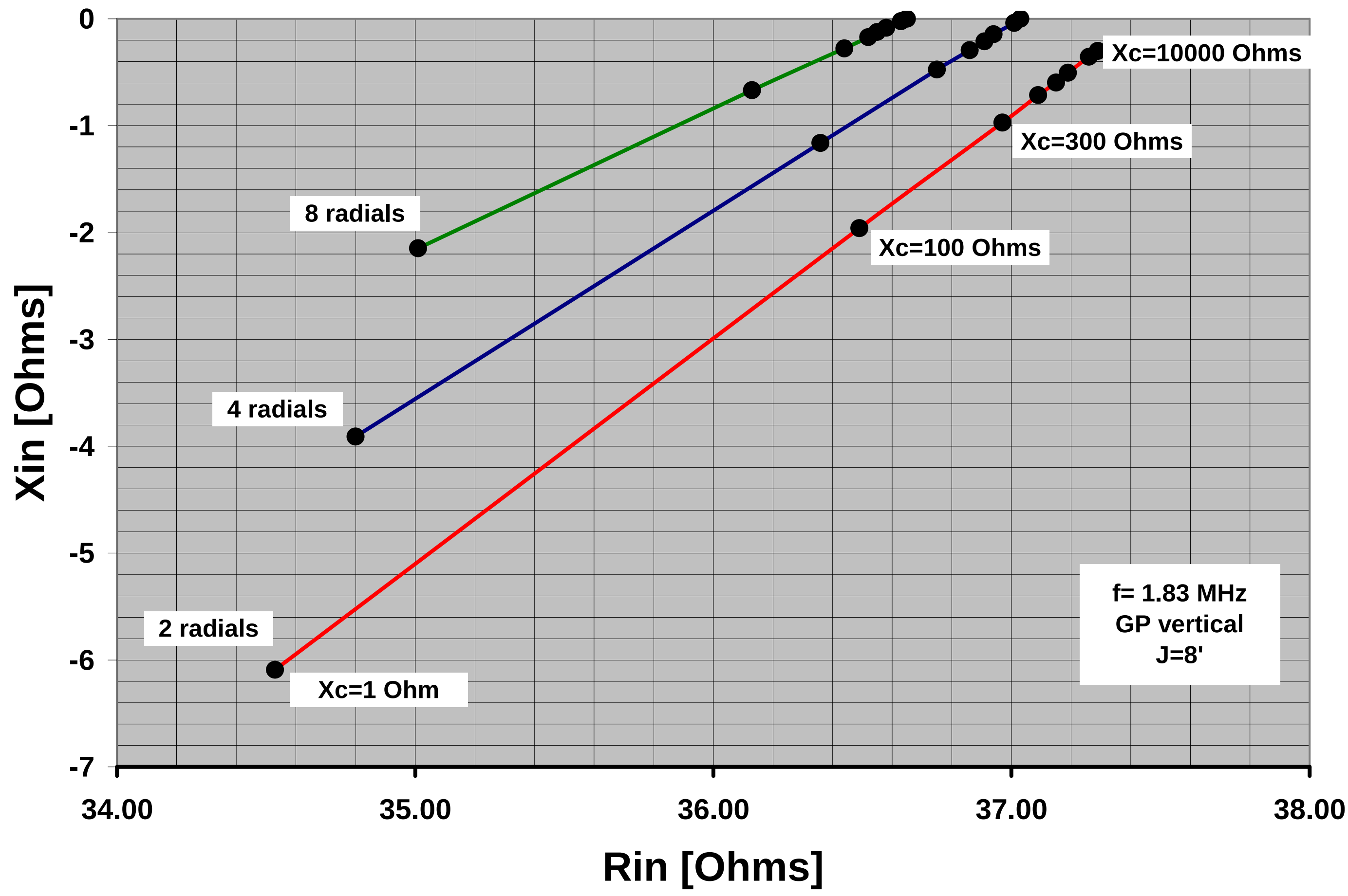

Figure 2 – Zin = Rin + j Xin for different values of choke reactance (Xc).

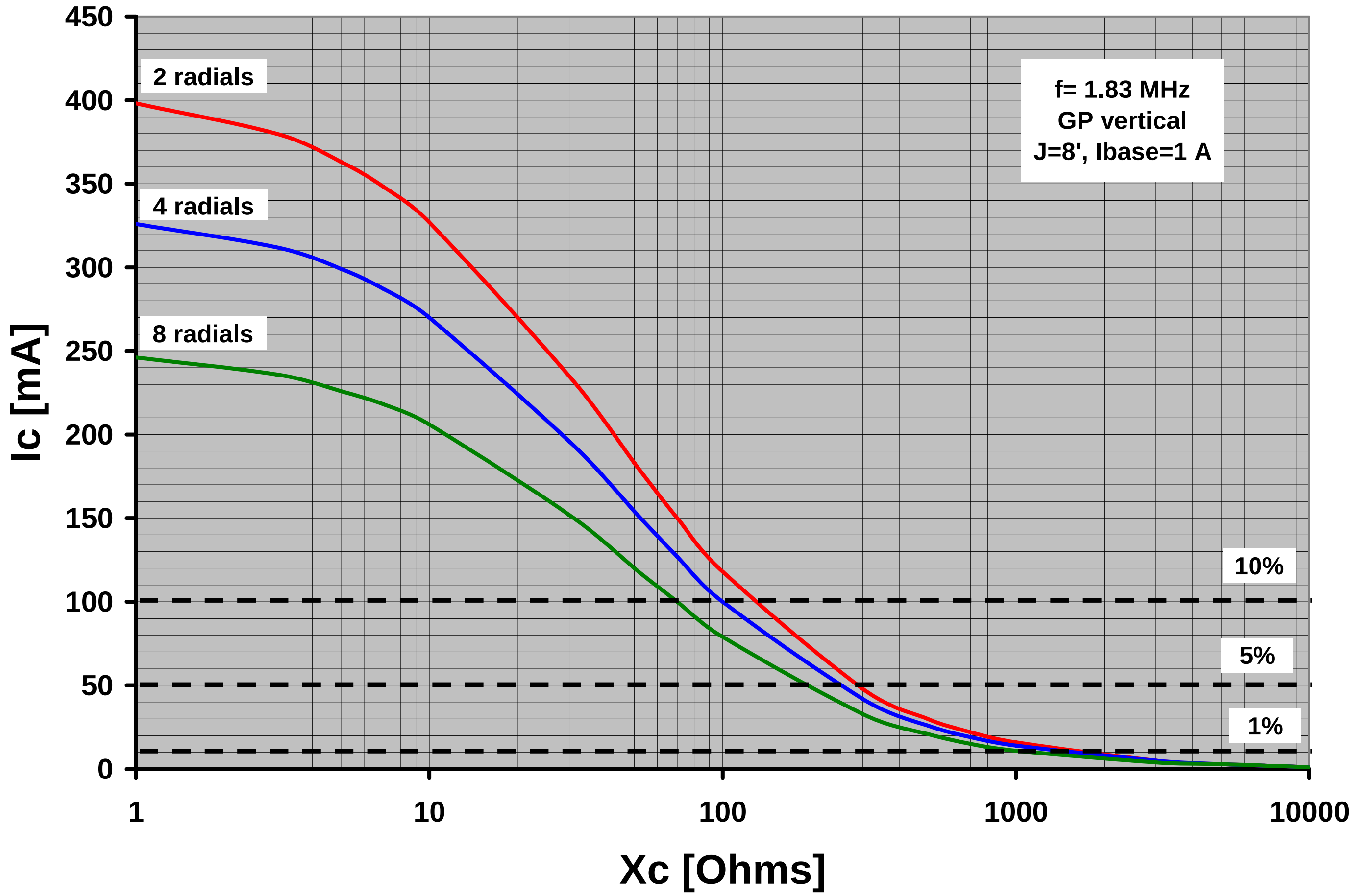

Figure 3 – choke currents(Ic) as a function of Xc.

No real surprises here. With no choke there will be substantial current on the ground wire (25 to 40% of Ib) and the feedpoint impedance (Zin = Rin + j Xin) is significantly different from the case of no ground wire or Xc infinite. The current in the ground wire goes down as the number of radials is increased. Adding a choke with Xc of only 100 Ohms substantially reduces Ic and the interaction with Zin. The question is "how low does Ic need to be?" There's no absolute answer to that question but from figures 2 and 3, for these antennas at least, an Xc in the range of 100 to 300 Ohms will bring Ic down to 5% of Ib or less which should be adequate.

At 1.83 MHz Xc = 1k represents an 87 uH inductor. Xc = 300 Ohms is a 26 uH inductor. How big is an 87 uH inductor made from RG213 coax to be used at 1500 W?

A choke example

Figure 4 shows a choke which I built for use on 160m. The choke is wound on a section of 8" PVC pipe. The actual diameter at the winding center is just under 9". There are a total of 29 turns of RG213 coax for a total length of 72' including tails. The winding length is about 13". This is a pretty hefty inductor!

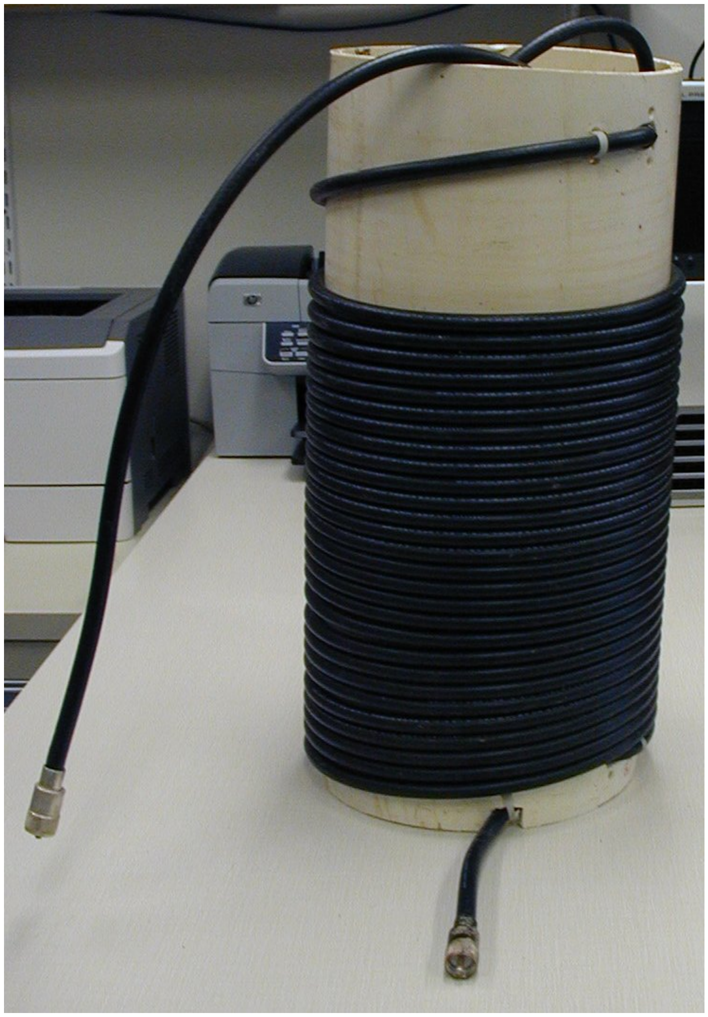

Figure 4, example of a 160m coaxial common mode choke.

The measured Lc = 97 uH. I also checked the value for Xc and the self-resonant frequency using an HP4815A RF vector impedance meter. The self-resonant frequency is just above 3.5 MHz although the resonance point is very sensitive to any stray capacitance. In any case, the resonance is still well above the 160m band.

Reducing Lc from 97 uH to 26 uH would substantially reduce the choke size. If you keep the winding length the same then L will vary with N^2 (N is the number of turns) that brings down the number of turns to 15. However, for a given N, if you shorten the winding length, the inductance will go up. The route to take is to reduce both N and the winding length. Although I was too lazy to redo the winding for 26 uh, I think you could get an Xc = 300 Ohm with about ten turns. The self resonant frequency would go up also. You could improve the Q of the inductor and raise the self-resonant frequency further by putting some space between the windings, a piece of ¼" nylon or Dacron rope co-wound with the coax would work fine. That choke would probably work very well on 80m as well.

There is a nice discussion on choke baluns by W2VJN in the 2010 edition of the ARRL Handbook, pages 20.18 and 20.19.