Shortened Dipole Study for Conditions On BVARC's Rag Chew Net

Full Article

by

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If you visit BVARC's Wednesday evening Rag Chew Net frequently, over the course of a year, you will find a different band condition greeting you every week you turn on the rig on. Most times local stations are strong, but, very occasionally, in the winter months especially, stations only a few tens of miles away are un-readably weak. Band noise (QRM and QRN) is one of the main factors contributing to an enjoyable net. Distance (100-300miles) stations are usual strong, but in the winter month's interference from other nets thousands of miles away can be a problem. In the summer, this QRN is ever present. Have your AF, RF and IF Shift controls readily available to adjust for the conditions.

Propagation is another factor and it is divided into 2 modes: ground wave and sky wave. On 3910 KHz, the ground wave is literally a few miles, then it fades off, but that will vary from night to night and is dependent on the antenna used (horizontal versus vertically polarized). As the ground wave fades out the NVIS (Near Vertical Incidence Skywave) mode takes over. NVIS mode seems to start, typically, at about 25 to 30+ miles and goes out 200+ miles. So these 2 modes create a donut affair around your station. A circle of close-in, strong, stations on the ground wave and then a ring of non-reception, surrounded by an outside ring of NVIS (sky wave) mode. All of the boundary's for each ring or circle vary from week to week. This explains why you hear every body one week and then close to nobody the next week. More often than not, conditions are favorable for a good net, but the "bad" propagation weeks make you appreciate the "good" propagation weeks. The net is an interesting and pleasant mix of OP's and topics, but it is all the more interesting, when you look at it in this "propagation" perspective.

So, for our "Rag Chew Net" conditions, the recommendation is a low horizontally polarized antenna that provides a ball shaped radiation pattern, covering both ground wave and sky wave modes. This is not to say: don't get on the air, if you run a vertical. Far from it, your vertical will work well on some nights and not on others, as will the recommended low dipole. It's low band HF. A beast of it's own, but fun to play with and study the interesting propagation and band conditions that present themselves and that will vary over time. Of course, dealing with these issues is not new, even 90 years ago they were concerned with the same problems: In a May 1925 QST article, Top Loading Antennas and Loops , by a non-Ham, W. H. Murphy, the author states: "The average transmitting amateur has simply got to fit his antenna into the space. Just what makes the best antenna does not concern him very much. He is interested in 'What makes the best antenna within my space'". So do what you have to do.

Since many hams are space challenged on city lots, a full size dipole is out of the question. A vertical has a small foot print and is a real option, but are there any other horizontally polarized options? K5LJ undertook a study of shortened 80M dipoles with the object of developing some 'rules-of-thumb' concerning short dipoles

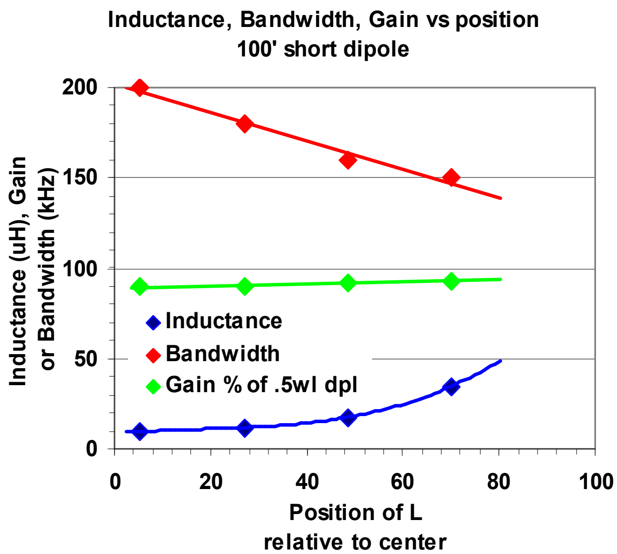
Rules-of-Thumb for Shortened Dipoles.

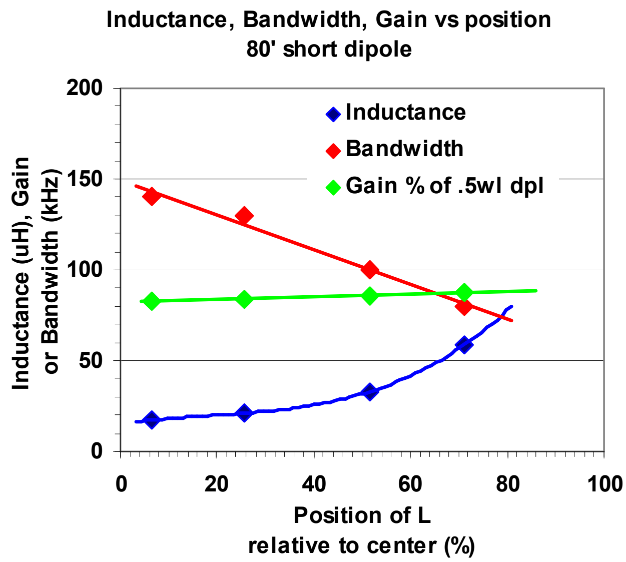
Where should loading coils be located in a shortened dipole?
What is the gain penalty, as the length is reduced?
What is the bandwidth?
What happens to the feed point impedance as the length is reduced?

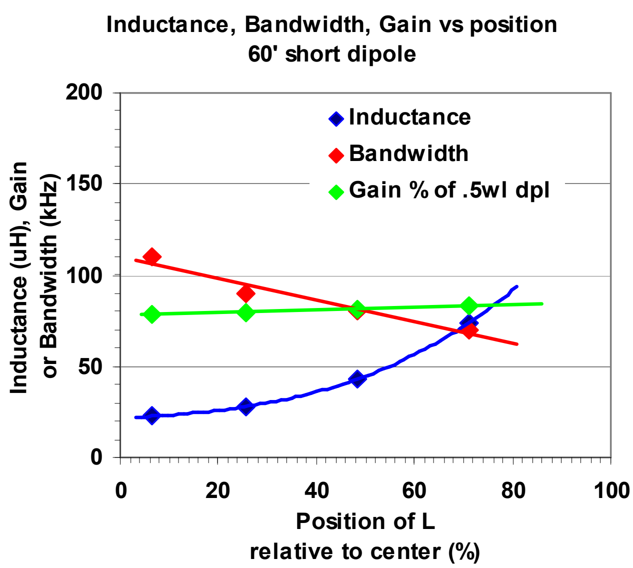
Using the modeling code EZNEC, I evaluated four different 80M antennas: 1) a full length dipole - 129' at 3750 kHz, 2) a 100' shortened dipole, 3) an 80', and 4) a 60' version. For the shortened antennas, I looked at the gain, bandwidth, and feed point impedance in free space as a function of placement of a loading coil in each half of the dipole. The loading coil inductance was adjusted at each position to obtain resonance (zero reactance at the feedpoint). The bandwidth was determined for each configuration by running an SWR plot in EZNEC and locating the frequencies at which the SWR had increased by 2. The bandwidth was then the difference between the highest and lowest frequencies.

I chose free space for the obvious reason that changes in the various parameters will be solely the result of the dimensional changes in the antenna. Ground reflection enhancement of antenna gain is also a bugaboo that clouds antenna discussion interminably. Interestingly, we do have good ground conductivity around here (at least I do out here in the boondocks) so even a dipole will have a gain over ground of 6-8dbi.

The results of this short study are summarized in the following graphs:

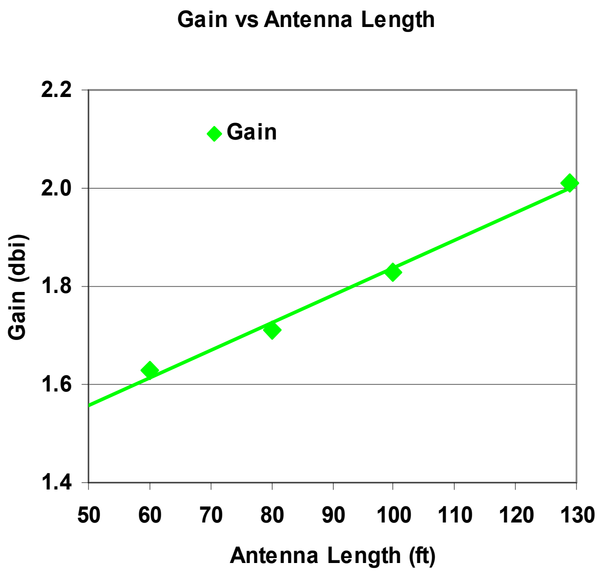


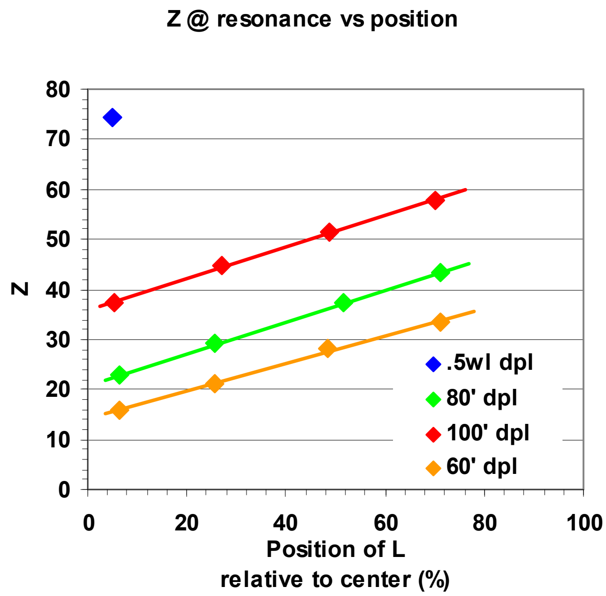




These 3 plots show how the position of a loading coil relative to the center of the dipole affects the amount of inductance required, bandwidth, and gain of the antenna for a given overall antenna length. A position of 0 means a loading coil is next to the feed point and 100 means it is at the very end of the element. Two loading coils are required – one in each element of the dipole. The bandwidth is defined as the range of operating frequencies that will result in a change of SWR of less than 2. The gain is expressed as a percentage of what would be had with a full sized .5WL dipole.

What we see here is that as we move the inductor outward from the center of the antenna, the amount of inductance required to resonate the antenna grows slowly at first but can become quite large beyond the half way point (~50%). Indeed, as the position of the inductor approaches the end of the element, the value approaches infinity! However, the bandwidth is greatest with the inductor near the feedpoint and declines linearly as we move outward. However, there is a (very) modest increase in the relative gain (compared to a .5wl dipole) as the loading inductor is moved outward. Comparing the figures shows that there is a modest decline in gain and bandwidth as the antenna becomes shorter.





The left-hand plot shows how the absolute gain of these antennas depends on total length. We see a .5db reduction in gain for the 60' antenna (with the inductor in the middle of each element) compared to the full sized dipole. Keep in mind that 1db is defined as the minimum audio signal level change that can be discerned by the human ear and also that one S unit on your radio is defined as 6db. This .5db difference would not be detectable in practice. The plot on the right shows how the feedpoint impedance (in free space) changes for the different antennas and how it depends on the placement of the inductor. We note that a 100' antenna, with the inductor in the middle of each element, has an impedance very near 50 ohm – an ideal match to 50 ohm coax. A full sized dipole would be better fed with 72 ohm coax. The 80' and 60' antennas will always have some mismatch regardless of the location of the inductor. Feedpoint impedance, however, is also a function of antenna height above ground and can vary dramatically with even modest changes in height. Even very short antennas can be effective radiators - the big problem is matching to them without exacerbating resistive losses. Heat is not the form of radiation we desire!

These results can be scaled to other bands and are generally applicable.

A shortened dipole will be defined as a dipole of less than .5WL at the operating frequency with loading coils inserted in each leg to resonate the antenna at the operating frequency. It is summarized here:

1) Make the antenna as long as you can.
2) Location of the loading coil only changes the characteristics of the antenna in a minor way. Placing them at the center of each leg is convenient but not critical. The coils should have a Q>200 (i.e. low loss).
3) The shorter the overall length, the larger the inductance required to resonate the antenna. The detailed article gives some information on typical values for a given length.
4) The shorter the antenna, the lower the gain relative to a full size dipole. However, even for a 60' long shortened dipole this reduction is only ~.5db – very hard to discern in practice. Keep in mind that one S-unit is 6db – so this reduction is 1/12 of an S unit.
5) The bandwidth (for an increase of 2 in SWR either side of resonance) will decrease. For a 60' antenna it will be about 40% that of the full size dipole.
6) The feed point impedance will decrease as the antenna becomes shorter – in practice this also depends on height above ground. Generally on the lower HF bands, incremental losses in coax are modest even for an SWR of 3 or 4:1.

A short dipole is a compromise, but not severely so (and nothing about its design is especially critical).

So, the rules-of-thumb for shortened dipoles are:

1) The shorter the dipole, the lower the gain – but this is a very modest effect.
2) The shorter the dipole, the narrower the bandwidth
3) The shorter the dipole, the lower the feed point impedance
4) The shorter the dipole, the larger the loading inductance required

The conclusion here is that any shortened antenna is something of a compromise, but there is no magic design that will ever restore lost paradise. The best recommendation is to make the antenna as long as possible, put a loading inductor in the center of each element and tweak the inductance value to get resonance where you want it, and then have fun.