

Antenna End Loading With Spiral or Helical Coils

Roger Sparks, W7WKB

When I began this experiment, I knew that spiral coils worked well for antenna end loading but was troubled by the often-found advice that “end loading with coils just isn’t practical”. I had no idea that spiral coils performed so *much* better than helical when used as end loading devices.

To get an idea of the performance difference, look at lines Spiral 25 and Helical 25 in the Data Table (see Figure 1). We see the same length of wire in both antennas but resonance at 107.22 MHz for spiral and at 134.21 MHz for helical wound. That’s a lot of difference in wire efficiency when antenna loading is the goal.

Coil Description	MFJ-226 Resonant Frequency MHz	Measured straight length inches	Measured coil length inches	2805 / freq in MHz = quarter wavelngth in inches	MFJ-226 Resistance Uhms	ratio of straight to quarter wave)	ratio of SPIRAL length to qtr wave	ratio of HELICAL length to qtr wave
spiral 0						1.00		
spiral 3	178.73	14	3	15.69	62.3	0.89	0.19	
spiral 5	174.68	14	5	16.06	72.2	0.87	0.31	
spiral 10	162.54	14	10	17.26	65.8	0.81	0.58	
spiral 15	140.95	14	15	19.90	57	0.70	0.75	
spiral 20	120.71	14	20	23.24	36.1	0.60	0.86	
spiral 25	107.22	14	25	26.16	43.4	0.54	0.96	
						0.50		
helical 0						1		
helical 3	181.43	14	3	15.46	65.4	0.91		0.19
helical 5	176.03	14	5	15.93	63.4	0.88		0.31
helical 10	167.94	14	10	16.70	71.3	0.84		0.60
helical 15	157.14	14	15	17.85	72.1	0.78		0.84
helical 20	142.3	14	20	19.71	63.9	0.71		1.01
helical 25	134.21	14	25	20.90	57.4	0.67		1.20

Figure 1. Data Table

The Concept and Experiment

I had wondered about antenna end loading with coils for many years, beginning about in 1954 when I held call sign WN7WKB. At some point, I was encouraged by Bill Petlowany’s WorldRadio (March, 1998) article “From out of the past – antennas with a new twist” [1].

Over time, antenna analyzers developed and I purchased a MFJ-226 Graphical Analyzer that has a very nice reference-plane shifting feature. Eventually, it dawned on me that I could see if there was any difference in coil performance between helical and

spiral wound coils by testing a series of uniformly sequenced coils. My plan was to build a series of loaded dipoles, identical except for the loading coils.

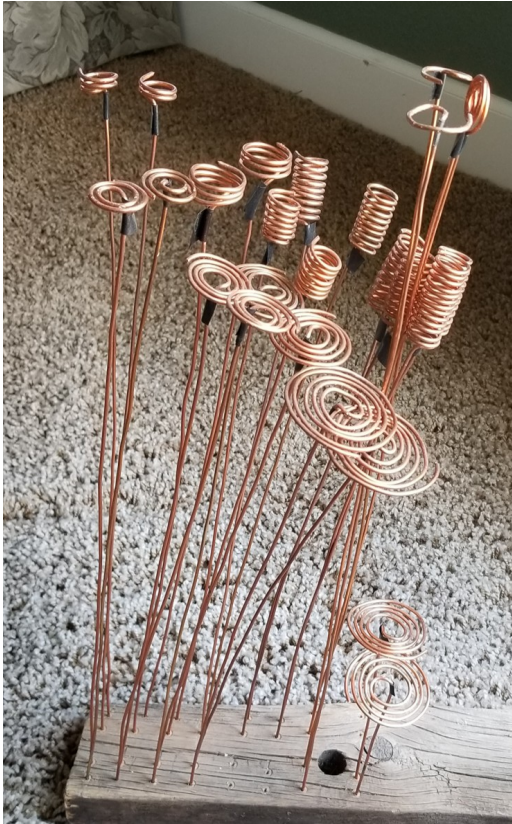


Figure 2. The collection of quarter-wave pairs.

I built six spiral loaded dipoles and six helical loaded dipoles, each having a straight length of 14 inches on each side of the feed point (28 inches end to end after mounting onto a test stand) (see Figures 2 and 3). The coils were each made using #12 copper wire except coil helical-3 which used #14 wire. Each coil was hand wound with wires spaced about $\frac{1}{4}$ - $\frac{3}{8}$ inches center-to-center. The helical coils were about one inch in diameter. The spacing of the wires was much less important than the length of the wire used in the coils.

I recorded the straight lengths, wire length in each coil, and, using the MFJ-226, the resonant frequency, resistance and impedance. The resulting data (except for the impedance) is shown in the Data Table (see Figure 1).

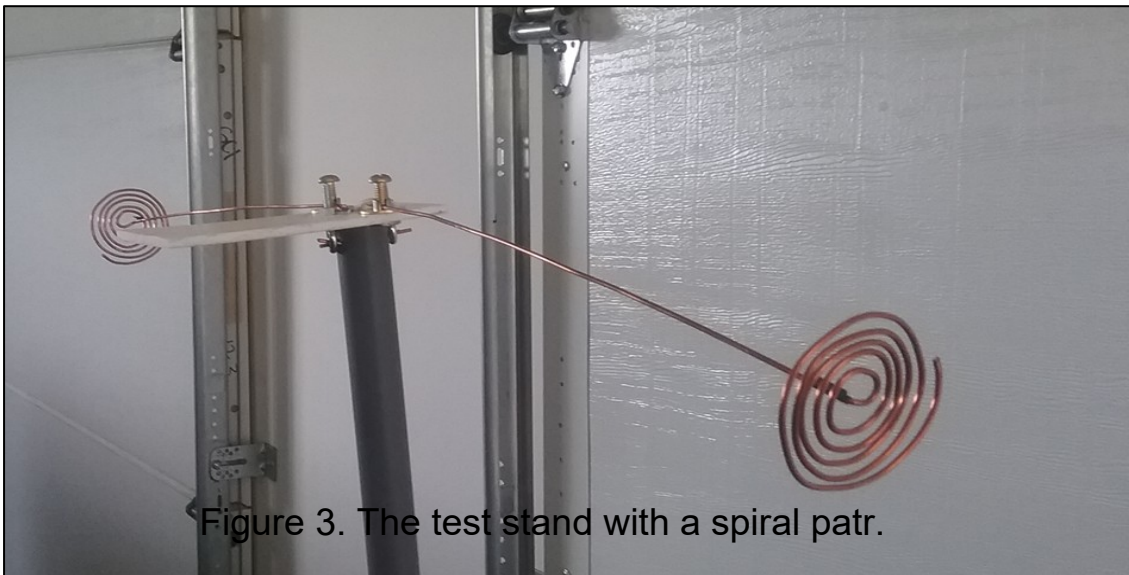
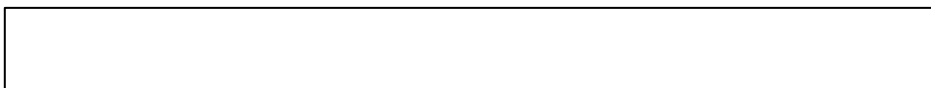


Figure 3. The test stand with a spiral pair.



I puzzled long and hard over how to present all this data. After a couple of false starts, I think it best to present a line chart focused on how to construct an end loaded dipole using either the helical or spiral method (see Figure 4). The difference in wire needed is obvious and goes a long way towards rationalizing the often repeated phrase “end loading with coils just isn’t practical”.

Notice that the lengths are all in fractions of a quarter-wavelength. Referencing all lengths to the quarter-wavelength was the only way I could think of to tie all the data together logically.

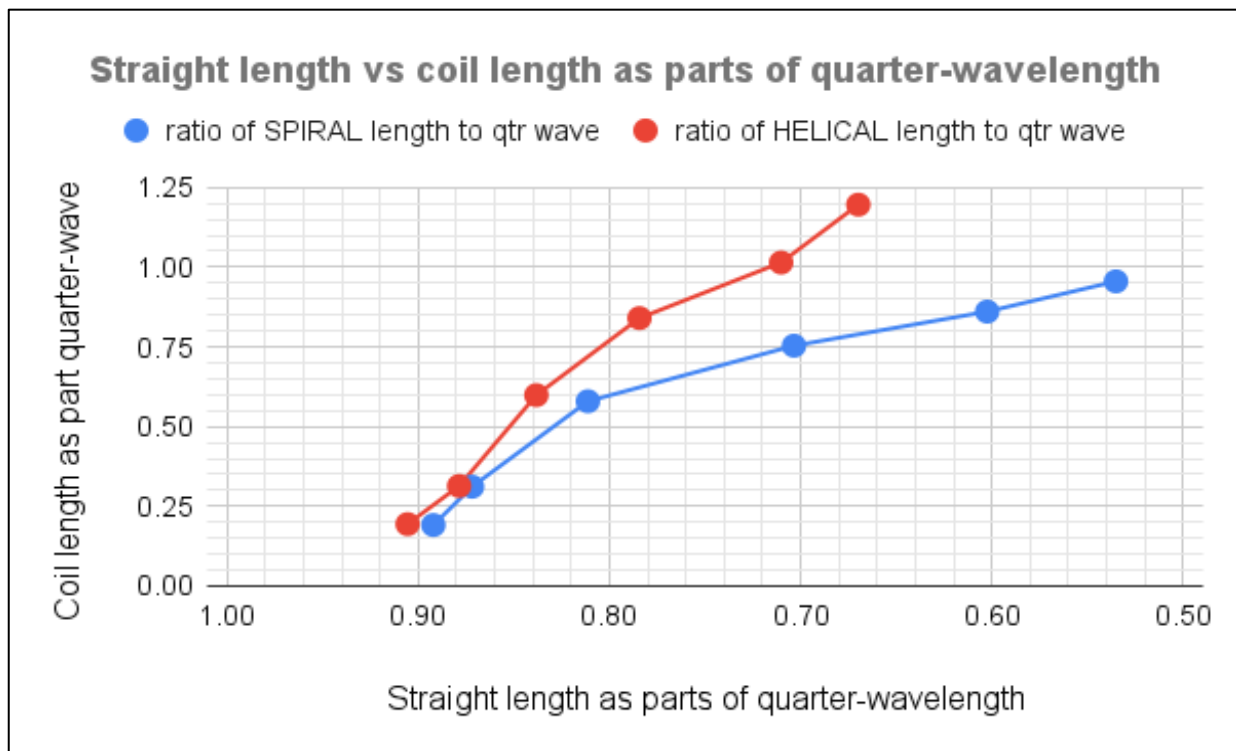


Figure 4. Line chart useful for designing both helical and spiral end-loading coils. On the horizontal axis, pick your straight length of quarter-wave. Then, go vertically to the spiral or helical curve, turn and go left to the vertical scale where you find the length of coil wire needed to achieve resonance.

To convert frequency to quarter-wavelength, we can use the free space velocity factor (2952 inches/MHz) or a lower velocity factor that includes real world environmental factors (2805 inches/MHz). I used the 2805 inches/MHz factor to build the line chart. There is about a 5% difference between the two numbers.

The chart may be read more intuitively if the X axis is relabeled as 100% at 1 (no shortening), 90% at 0.9, 80% at 0.8, ... , 50% at 0.5. If we want to hold the resonant frequency constant, any effort to shorten the straight section necessitates adding wire to the coils, which is the situation we see displayed on the Y axis.

[For example, we may want the new antenna to be 70% of the length of a full quarter-wave antenna. Go into the chart to find that the spiral coil should contain about 0.75 parts of a full quarter-wave of wire.]

Extending These Curves Toward Counterpoise Size

At about the 50% reduction point, the spiral loading coil needs to have about a quarter-wave of wire in place. From Hebner [2], we learn that a quarter-wave of wire in a spiral coil is nearly enough to be a counterpoise for a vertical antenna. I don't think I have enough data to fill in the gaps here.

For a while, I had a 160M, spiral-top-loaded, 40 foot vertical with a little over a quarter-wavelength of wire in the coil. Matched with a cobbled together tuning network, it worked well but I never measured the resistance. I never followed up on that project.

Some Ideas on Building Coils for Lower Bands

Spiral coils on lower bands will be too big to be self supporting, even if made from tubing rather than wire. I had good success with supports made from PVC pipe. I sawed slots wide enough to accept the wire diameter into the pipe at the desired spacing. If the slots are deep enough, a zip tie can be inserted to keep or key the wires into place.

My jigsaw blade cut slots that were too thin for #12 wire so I brazed a second blade onto the first, making the blade double thickness. With the wider blade, I easily cut slots wide enough to accept the wire diameter.

The center-to-center wire spacing is not at all critical for the spiral coils. The length of the conductor is the critical factor.

A Second Resonant Point with Longer Spirals

The typical dipole antenna has a fundamental resonant frequency with additional resonant locations at odd harmonics higher. The spiral end-loaded dipole can be demonstrated to have higher order resonance points closer to an even harmonic higher.

Knowing this, I made two dual band antennas, one for 20-40M and one for 10-20M. Both worked well but, at least on the 20-40 version, I needed an antenna tuner to make a good SWR match. I never made the effort to tune either dual-band version to find optimum performance.

The same second harmonic resonant frequency effect may be found on helical wound coils but I did not observe it.

Conclusion

Spiral coil end-loading is far more practical than helical end-loading, and offers the possibility of dual band antennas. Spiral-coil end-loaded verticals are also practical.

The whole subject of end loading with spiral coils is largely unexplored and has potential for further development by amateur radio experimenters. I am looking forward to reading future articles describing adventures with spirals.

[1] Bill Petlowany, K6NO, <https://www.qsl.net/wa2lqo/nlaug03.html>

[2] Greg Hebner, AG5FE, "A Simple Vertical Antenna With a Spiral Counterpoise", QST, May 2022, pg 33.

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Roger Sparks, W7WKB
Email rsparks@elltel.net

Roger Sparks, W7WKB, was first licensed in 1954 as a Novice. He graduated from University of Idaho in 1959 with a BS Agricultural Engineering. He farmed for 51 years, now retired. He served as an elected commissioner for the Kittitas County Public Utility District and represented the Board on the Energy Northwest Board of Directors. You can contact Roger at rsparks@elltel.net.

Caption Collection:

Figure 1. Data Table with methodology for converting frequency to parts of quarter-wavelength.

Figure 2. The collection of quarter-wave pairs.

Figure 3. The test stand with a mounted quarter-wave spiral pair.

Figure 4. Line chart useful for designing both helical and spiral end-loading coils. On the horizontal axis, pick your straight length of quarter-wave. Then, go vertically to the spiral or helical curve, turn and go left to the vertical scale where you find the length of coil wire needed to achieve resonance.

All photos and charts are provided by the author.