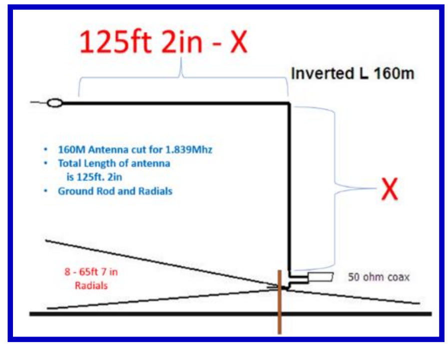
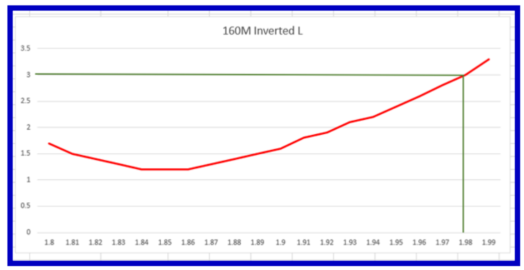
The "No-Excuses" 160 Meter Vertical

By AJ8B, Bill. Excerpts were used with permission by John, K6MM. Johns original article appeared in QST, June 2009.



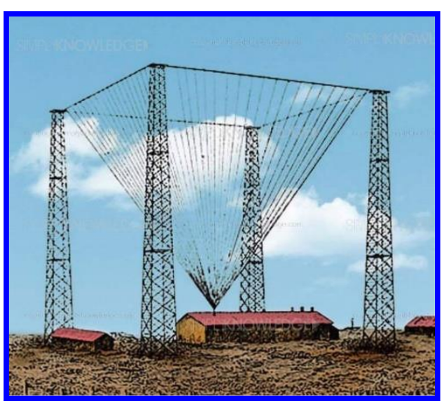
(AJ8B) In my quest to enjoy 160M, I originally constructed an inverted "L" with the dimensions shown in the drawing. This worked well and certainly got me on 160M, but I felt that the performance was lacking. I was only able to get the vertical portion up about 40 feet which meant that the long side was 85 feet long.

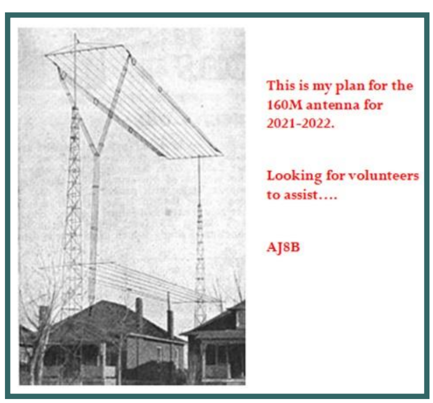
This was a simple installation, and I was able to keep it up from November 1st to April 1st. However, at some point, the ¼ wave radials interfered with the ever-growing grass!



The SWR for the Inverted L is shown in the diagram. I know that SWR is a complex measurement and that there are many factors that affect it and many opinions about how important it is. However, since I was pruning the length of the antenna and had to use some figure of merit, I chose an SWR of 3. This would allow me to use as much of the antenna as possible without a tuner. The SWR diagram shows an SWR of less than 3 up to 1.9M. Not too bad.

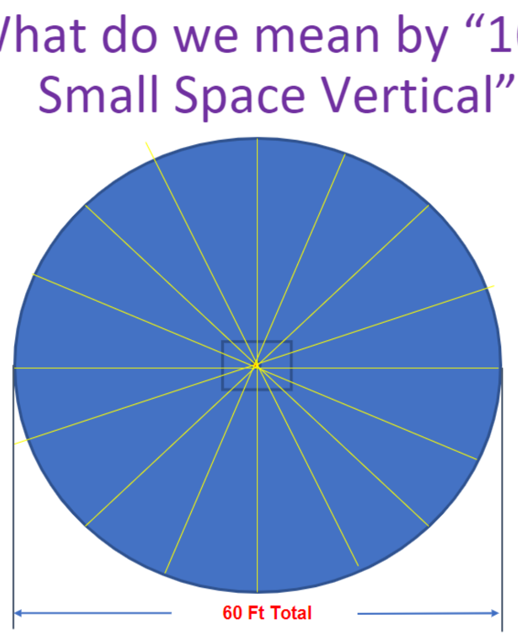
With this arrangement, I worked 29 entities and 48 states on CW and FT8. I had several other designs that I simply could not implement due to their complexity. Those are shown in the 2 drawings below:





Of course, I am kidding on those two. However, I did want to try to overcome some of the directional issues associated with the Inverted L. In the late 70s, my OM (K8DWE – SK) and I had built a helically wound vertical for 40 meters for a small space. It worked well and certainly allow the user to get on to 40 meters and enjoy some level of success. I decided to research a helically wound design for 160M. Very quickly I came upon a design by K6MM, John (k6mm@arrl.net).

When I read John's article, it struck me that it would be an interesting test to compare the "short" inverted "L" against the helically wound vertical consisting of 256 feet of wire. I decided to build John's vertical.



The details of the construction will follow. I already had a 500' roll of #14 wire so I started to wrap it after painting the 25 feet of PVC tubing and fitting the sections together. I am not the most coordinated person and have very large hands which make fumbling around with spools of wire etc. a challenge. The wire kept sliding and would bunch up in some places and be spaced out too much in other.

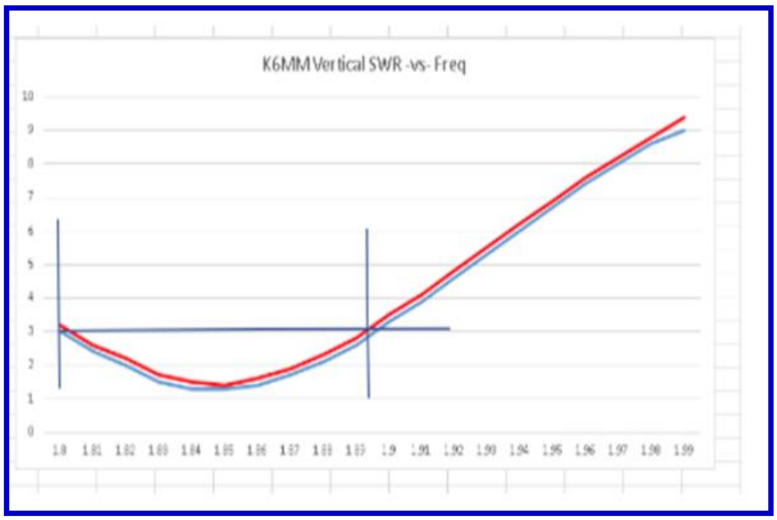
I enlisted the help of my coworker, Jeremy (a non-ham for now), and he designed and built a wire guide that could be attached to the PVC pipe, keep the wire consistently spaced, and keep it in place. He used his 3 D printer to print the wire guide as shown in the picture. The length is approximately 7". As the mast is 24.5' tall, this translates in to 42 of these wire guides. The latest "version" of the wire guide is a bit longer and only has one mounting hole in the center, not at the ends. I used a very small screw to hold the guide on since the tension of the wire will really do that job!

The picture shows a mid-section wrapped with the wire guides in place. I did use electrical tape every few feet as insurance. Once I dropped the feed spool and achieved the "slinky" effect. The tape helped to keep this under control.

The wire guides (and screws) added about a pound and a half to the overall weight and help me to control the wrapping.

I wanted to have the ground plane in place before mounting the antenna. Joe, W8GEX, had a DXEngineering ground plate and pre-cut radials bagged up for me. Took me no time at all to deploy 16 radials. Thanks Joe!

Using the same criteria that I used for the Inverted "L", I took SWR readings across the 160M band without a tuner. The results are shown in the graph. I can use this antenna without a tuner from 1.8M to 1.9M.



My result after the first week were very good. I worked 26 states and 10 entities, split between CW and FT8. Of course, propagation has a lot to do with this and it is only a sample of a few days, but I am optimistic. It is noisier than the "L", but signals are several S-units louder. To date, I have worked an additional 31 entities, 15 Zones, and into JA, and VK.

I contacted John, and he gave me permission to use the design, publish about it, and to present it as I would like. I decided to take him up on his offer and excerpts from the original QST article follow.

Overcoming my Excuses

(K6MM) I am an avid contester but had no antenna for 160 meters. In fact, I was a bit cynical about ever being able to put up an effective 160-meter antenna from my rather small California city lot. My NCCC contesting buddies, however, convinced me that I was missing out on some big-time fun with the ARRL 160 Meter, CQ 160 Meter, and Stew Perry Topband Challenge contests. No more excuses. It was time for me to get on the Topband Train too.

A review of the literature on 160-meter antenna designs leads to the usual discussion of dipoles, inverted-L's, T's, V's, loops, deltas, and verticals.

After thinking about my own QTH constraints I found myself revisiting the HWV option and settled upon a design often discussed but not often deployed in the US: a helically wound vertical antenna using PVC tubing.

Wire Wisdom

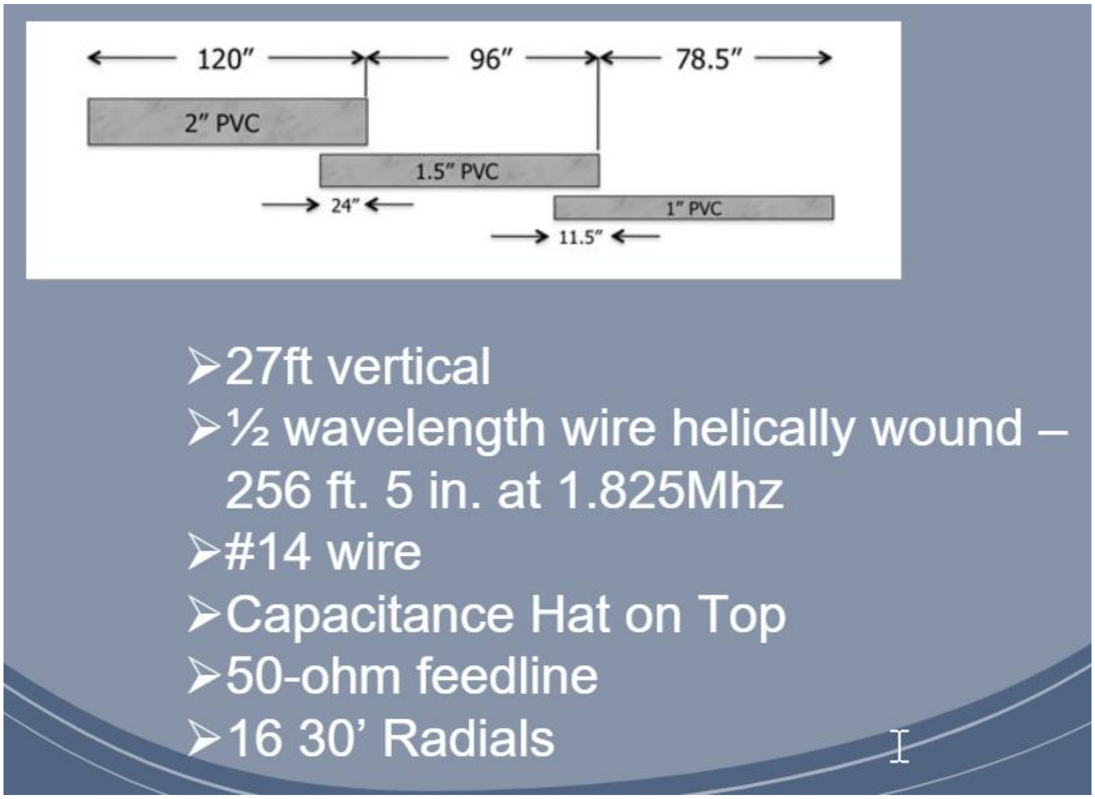
There is no hard-and-fast formula for determining the amount of wire needed to establish resonance in a helical antenna. The relationship between the length of wire needed for resonance and a full quarter wave at the desired frequency depends on several factors. Some of these are wire size, diameter of the turns, and the dielectric properties of the form material. Experience has indicated that a section of wire approximately one-half wavelength long, wound on an insulating form with a linear pitch (equal spacing between turns) will come close to yielding a resonant quarter wavelength. Therefore, an antenna for use on 160 meters would require approximately 260 feet of wire, when spirally wound on a support.[1]

Add other possible challenges like narrow bandwidth, poor feed point impedance, radiation resistance, efficient top hat capacitance, mechanical constraints, sufficient ground radial system – and you could easily become a Topband curmudgeon. But then you'd miss out on building this fun antenna – which really works!

To try and get a first approximation on a final HWV design, I used modeling software developed by Reg Edwards, G4FGQ.[2] His program models and predicts the performance of a helically wound vertical antenna, mounted immediately above a ground plane, top- capacitance-loaded with a vertical rod or whip. Enter these variables: height/diameter of the helical coil + # turns & diameter of wire + length/diameter of end-loading rod, and you get back theoretically useful data: ¼ wave resonance frequency, length of wire needed, helix wire pitch, capacitance/inductance data, feed-point impedance and expected bandwidth.

Let's Get Started

The remainder of this article describes the construction and performance of a very simple but effective HWV antenna for 160 meters. In a nutshell: The antenna is made by telescoping three 10-foot PVC sections together, helically winding it with ½ wavelength of antenna wire, attaching a capacitance hat to the top, and feeding it with a 50-ohm feed line against 8 ground radials. The entire construction can be easily completed in just one day using very simple tools.



Antenna Summary

Construction

Figure 1. PVC Before

Step 1—PVC Painting The antenna is made from three 10-foot sections of readily available PVC tubing in three diameter sizes: Top Section = 1-inch, Middle Section = 1½ inches, and Bottom Section = 2 inches. To make this antenna environmentally & stealth friendly, the three PVC sections were spray-painted green by suspending each 10-foot section from two pieces of nylon rope between two branches of a convenient backyard tree. Brown paint would work just as well. Figures

1 and 2 show a PVC section before and after painting. All three 10-foot sections were allowed to thoroughly dry before proceeding (see Figure 3).

Figure 2. PVC After

Step 2. Bottom Section: Coax, Antenna and Ground Connections

The bottom 2-inch PVC section is prepared for both ground and coax connections by drilling the necessary mounting holes. A PVC cap is placed on the bottom of the 2-inch diameter PVC tube, and then, using a felt-tip marker, a circle is drawn around the PVC just above the border between the bottom cap and PVC section. This "marker" ensures that subsequent drilled holes will clear the bottom PVC cap.

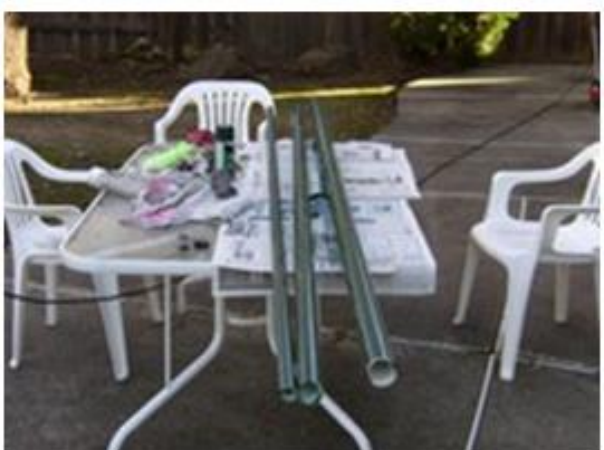


Fig 3. Painted PVC Pipes

Coax Connection: The PVC cap is then removed, and then holes are drilled for the SO-239 connector and 4 attachment screws. The SO-239 hole is centered about 2½ inches above the marker (see Figure 4).


Figure 4. SO-239 Connector

Bottom Antenna Binding Post: One 1/8-inch hole is drilled for the antenna binding post, placed 2 inches above the marker. A red binding post was used for the antenna connection.


Fig 5. Binding Posts & Internal Wiring

Ground Binding Posts: Two 1/8-inch holes are drilled for the ground posts, each placed 1½ inches above the marker. Black binding posts were used for ground connections.

Summary: The 3 binding post holes (i.e., 1 antenna + 2 ground) are placed equidistant from each other around the PVC section. The antenna post and ground posts are staggered by about ½ inch to avoid any possibility of shorting (see Figure 5).

Step 3. Wiring: Coax Connector and Antenna Post

One end of a 4-inch piece of #14 wire is soldered to the center connector of the SO-239. The other end is then soldered to either a spade or ring lug. The wire is then pushed through the prepared SO-239 hole in the 2-inch PVC tube, and the SO-239 connector secured to the PVC tube using only 3 of the 4 mounting holes. The free end of the insulated wire is connected to the inner section of the red antenna post using the spade or ring lug. After securing the antenna post a binding nut, the connection can be soldered (see Figure 5).

Step 4. Wiring: Coax Connector and Ground Post

A 6-inch section of #14 insulated wire is soldered (or crimped) to spade lugs on both ends.

One end is connected on the outside of the PVC to the remaining SO-239 screw and secured to the PVC. The other end of the #14 wire is connected to the closest black ground binding post on the outside of the PVC.

Inside the PVC, another piece of #14 wire is attached between the 2 ground binding posts. This essentially connects both ground binding posts and the coax base together. Check to be sure the antenna and ground connections inside the PVC are clean and not touching each other. Braided coax, such as RG-58, can also be used instead of the #14 wire for ground post connections. At this point, the SO-239 and all binding posts should be tightened and secured. For extra strength and protection, the binding posts can also be glued to the PVC, both inside and outside (see Figure 5)

Step 5. PVC Mast Preparation and Assembly

The Top, Middle, and Bottom sections are assembled using a high-tech solution: duct tape. I used Gorilla Tape10 for wrapping because it uses two layers of adhesive and two layers of fabric backing to make it much stronger than standard duct tape.

First, the 1-inch diameter PVC tubing is shortened from 10 feet to 7 feet 6 inches by cutting off 2 feet 6 inches from one end. Duct tape is then wrapped around the tubes as follows:

For the Top Section (1 inch diameter tube) = Two wrappings. First wrap = 2 inches from bottom of tube. Second wrap = from 9½ to 11½ inches from the bottom of the tube.

For the Middle Section (1 ½ in diameter tube) = Two wrappings. First wrap = 2 inches from bottom of tube. Second wrap = from 22 to 24 inches from the bottom of the tube.

The 3 PVC sections are then telescoped together. When assembled, the Middle Section will extend 24 inches into the Bottom Section, and the Top Section will extend 11½ inches into the Middle Section. It's important to use enough duct tape to ensure a good fit between the PVC sections.

The next step in PVC assembly is to further secure the "joints" with a bolt and nut. The lower joint (between the Middle and Bottom sections) is secured by drilling a ¼ inch hole through both PVC sections about 12 inches from the top of the 2 inch diameter Top PVC section, and using a 3¼ inch bolt, nut, and washer to fasten the sections together.

The middle joint (between the Middle and Top sections) is secured by drilling a similar hole, about 6 inches down from the top of the 1½ inch diameter Middle PVC section, and using a 2¾ inch bolt, nut, and washer to secure the joint.

Top Antenna Binding Post: Similar to the Bottom antenna post previously mentioned, a Top antenna post is prepared by drilling a 1/8-inch hole one inch from the top of the Top PVC section. A red-capped binding post is attached to it, using a nut and glued to secure it. The helically wound antenna wire will be connected to this post, which will also be the antenna- to-capacitance hat attachment point.

Step 6. Helically Winding The PVC

With the sections assembled and fortified, the antenna is ready to be helically wrapped with wire. As previously mentioned, experimentation with HWVs has shown that a half wavelength of wire is often needed for quarter wave resonance, assuming the turns are evenly spaced. At a desired resonance frequency of 1.825 MHz, 256 feet 5 inches of wire is required for a 160-meter vertical, using the formula 468/freq. For this first version of the antenna, I chose #22 insulated wire for the antenna – I had a good supply sitting in the garage.

(AJ8B) At this point, I attached the wire guides along the length of the sections. Because of the slick paint and the 3D printed plastic, they will tend to slide about. I used one wrap of electrical tape per guide to help hold it in place. A picture of the section is show in the picture.

Wrapping begins by first attaching the antenna wire to the Bottom Antenna Binding Post of the 2-inch PVC section using a spade or ring solder lug. The wire is then wound from bottom to top. Wire wrapping is not a difficult step but does require a bit of patience. It's best not to rush this part of the project.

The end of the wire at the top of the antenna is then soldered to a spade or ring tongue and attached to the Top Antenna Binding Post with the red cap at the top of the 1" PVC section.

Step 7. Top Cap Preparation: Capacitance Hat

(K6MM) The square hat construction begins by drilling four 1/8-inch hole 90 degrees apart in the 1-inch PVC cap, about 1 inch from the bottom. An additional 1/8-inch hole is drilled next to one of these holes. The brass rods are inserted into the cap, forming an "X". A pair of pliers is helpful here, as it will be a snug fit, which is what you want. Next, a 6-inch piece of #14 insulated wire is stripped on one end and soldered to a spade or ring lug on the other end. The stripped end is slipped through the remaining 1/8-inch hole and wrapped securely around the "X" junction of the two brass rods inside the PVC cap, where everything is securely soldered (see Figure 10) The brass rods are tied together externally by connecting them together with #14-gauge bare copper wire in two places: the tips of the rods and also midway between the rod ends the and PVC cap. The bare copper wire is soldered to the brass rod at all 8 intersections, to complete the "square hat" (see Figure 11).

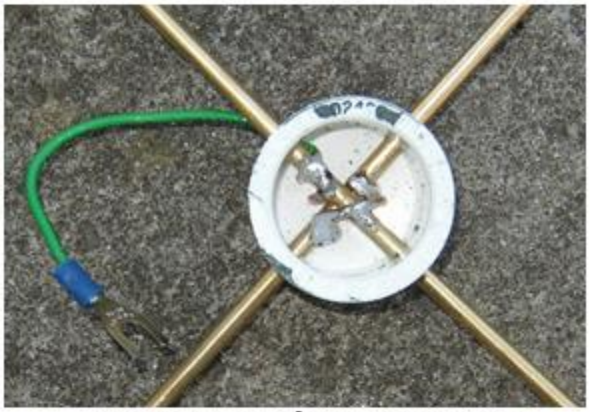


Figure 10. Inside Top PVC Cap

Finally, the PVC cap is attached to the Top Section of the antenna, and the capacitance wire secured to the Top Antenna Binding Post using the spade or ring lug. For maximum result, it's important to have a good electrical connection between the antenna wire and capacitance hat.

Figure 11. Completed Square Hat

Step 9. Bottom Cap Preparation

The bottom cap is used to support and protect the antenna. A ¼ inch hole was drilled in the center of a piece of scrap plywood (about one foot square).

Figure 13. Showing Threaded Rod

Another ¼ inch hole was drilled in the bottom of the 2-inch PVC cap. The threaded aluminum rod was trimmed to 12 inches, and run through the bottom PVC cap, and then through the plywood (see Figure 13). Nuts and washers were attached on the threaded rod inside the cap and on the other side of the plywood. When tightened, only 2 inches of rod was left inside the cap, to ensure that the antenna and ground wiring in the bottom section of the mast would not be disturbed (see Step 2). About 10 inches of threaded rod was left sticking out from the bottom of the plywood (see Figure 13). The plywood base serves as a stabilizing platform to ease final installation of the vertical. By gently standing on it and pushing, you can easily drive the 10 inches of threaded rod into the ground.

After the PVC sections were bolted together, and completely wire wrapped, the capacitance hat was attached to the top of the antenna, including the capacitance wire-to-antenna binding post connection. The antenna is now ready for final installation. The bottom 2-inch PVC cap/plywood base was set in the ground at its mounting location. Bracing the bottom against the ground, the antenna was carried to the PVC cap/plywood base and carefully set into the PVC cap. One person can carry & mount the antenna but it's a bit easier with two folks (see Figure 15).


Fig 15. Installed and Neighbor Friendly

My QTH required bracing the mast to my back fence and securing it at the 6 foot point with nylon rope. To keep the vertical, "vertical", a section of nylon rope was also attached at 12 feet using a convenient tree limb and the rope secured at ground level. Final guying/bracing will depend upon your antenna placement.

Radial Wires: This antenna does require some ground radials. Of course, use as many as your QTH allows. I started with four 1/4 wavelength ground radials cut for 160 meters and have expanded that number now to eight, using #16 stranded insulated wire. Spade lugs are soldered to ground radials which are then attached to one of the two ground posts. Because of the geometry of my property, my radials cover only a 180-degree arc, but they work pretty well.

Initial Readings: After attaching a 6 foot piece of 50-Ohm coax, an MFJ 249B antenna analyzer showed resonance close to 1.790 MHz The antenna wire was adjusted at the bottom to bring the resonance closer to 1.830 MHz Running 500 watts through this antenna without a tuner showed a 50 KHz bandwidth, with <2:1 SWR. With a tuner, the antenna can be adjusted anywhere from 1.800 to 1.900 MHz with an SWR under 2:1.

ON THE AIR: So how does this Helically Wound Vertical for 160 meters perform? From the West coast, it's a solid performer throughout the North America. I have worked all 50 states, Canada, and Mexico during the last year with it, almost all confirmed via LoTW. I was awarded First Place, Single Operator, Low Power for the Santa Clara Valley section in the 2007 ARRL 160 Meter contest. In the 2009 CQWW 160 Meter contest, I worked 46 states and 7 countries using 600 watts in just a few hours of operating. For DX, with limited operating time, I have worked 30 countries. Overall, this antenna plays well to the Far East, South Pacific, Eastern Russia, Caribbean, and Central/South America. Europe is the most difficult region to reach from my location, but that's generally true for most West coast stations.

Am I the loudest signal on the band? No. Can I compete in pileups with folks having better antennas or higher power? No. But am I having fun on Topband using a homebrew antenna that generates memorable QSOs? You bet!

Summary – A Helically Wound Vertical is not "the" perfect antenna for 160 meters, but for a small lot, or where CC&R's are strictly enforced, this easy-to-build vertical is a good alternative to an inverted-L or dipole. During the last year, I have helped other hams around the country get on the air with this HWV design for 160 meters.[11]

This unsolicited comment from Armand Sun, K6IP, is typical of the feedback I've received:

> "I finally put up the HWV antenna and I'm happy to report that it works FB. Mine has two feed options: ladder-line or coax. I'm currently feeding with ladder-line and one elevated radial from leftover wire on the spool and the results are excellent! It takes a KW from 1.8 - 1.9 MHz I painted mine olive drab with black #14 wire so it's pretty stealthy. I would imagine brown would be good too. Sometimes the traditional designs just don't blend well with the existing antenna farm. A Helically Wound Vertical is a good option for small lots or for those with antenna restrictions. Thanks for the design. It was fun to build and just what I needed for a Topband solution."[12]

So, no more excuses for Armand -- or Me. Now how about you?

John Miller, K6MM — Originally Published in QST, June 2009, pages 32-36.

Notes from K6MM Article

1 *The ARRL Antenna Book*, 21st Edition, 2007, p. 6-38.

2 R.J. Edwards, G4FGQ. (a) "Model and Predict Helically Wound Vertical Antennas". http://www.smeter.net/antennas/helical-modeling.php August 2, 1997; (b) "Very Short, Helically