Re-visiting the Double-L

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In 1999, I published a short piece in the 'Butt about what I had hoped would be a proposal to end the excuse for not getting on 160 meters. It was (and still is) a simple vertically-polarized antenna for 160 meters that doesn't need a "ground" system...and works. The original idea was to have a configuration that got people on the low bands with decent signals, a minimum of complication and without a lot of cost connected with trying it out. It was centered on 160-meters and I added the 80-meter antenna because it was essentially free.

The idea was:

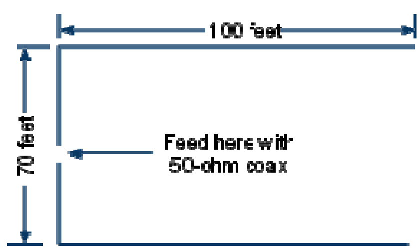
> *Lay out a 270-foot wire dipole, haul up the top corner (35 or so feet above the feedpoint) with a suitable halyard, attach and dress a 50-ohm coax feedline, attach the rest of it with ropes or heavy strings, trim it to resonance, and get on the air.*

I called it a *Double-L* because it can be looked upon as an inverted-L fed against an L. *It's a shortened half-wave vertical with a wide-spaced transmission line as an end load.* Because it's a half-wave antenna, it does not depend on a current return path that includes the lossy earth. For the vertical length, it has the highest attainable radiation resistance, and therefore the highest possible efficiency for a given near field earth loss. It works best when the vertical portion is between 70 and 90 feet in extent. It requires two fairly tall supports, and has the virtue that it's easy to adjust to resonance by trimming the bottom horizontal leg.

This is a *half-wave antenna.* As such, it does not use the ground as part of the return current path. Ordinarily, feeding a half-wave vertical is tricky because the feedline passes close to the high-voltage portions of the antenna. One usually gets around that problem by feeding it at the end, as with a J-pole, Ringo or other variants. This configuration can be fed with coax directly in the center because the ends of the antenna are kept far from the feedline by the geometry.

In contrast, an inverted-L has the current peak at ground level, depends on a return path that includes, instead of avoiding the ground. That arrangement is often lossy, and, for the same vertical length, has half the radiation resistance of the half-wave configuration. Much of the folklore associated with grounded verticals has to do with avoiding loss in the return path. The Double-L avoids much of that loss.

The L-over-L geometry is simple:



Original design
for 160 meters

It's hard to understand how such a simple antenna can be complicated. Since the original article was published in the 'Butt, it has been published in a few other places.

As a result enough people have now used the *Double-L* antenna over twelve years and in enough different places, to know that it works and works very well.

I use #14 plated, stranded teflon-covered wire for mine. It's hung from the top corner by a strain relief made of a foot of braided dacron rope attached to the antenna wire with solid wire, either copper or aluminum, wrapped around the rope and antenna wire. It's self-supporting, if you are careful to keep strains off the radiating wire. I hold the bottom corner in place by running the wire through a loop of rope that ties the corner to the ground. I like to use a bowline to form the loop and a double half-hitch to hold the bottom of the rope. Anything more complicated is unnecessary. My current one has been in place for about eight years.

The idea of a full-sized quarter-wave vertical with 120 half-wave radials was cooked up by Brown around 1939 to give broadcast engineers a design that would assure a workable antenna every time. Brown's approach will not work much better than this simple configuration, none of the variants of which I'll show you below require any radials. The variation from the most costly and complex to this simple variant is no more than about 2 dB. That fact has been covered by other writers such as Cebik and Severn, who have done meticulous work proving what basic physics tells us, and I won't repeat their good work here.

The vertically-polarized radiation is omnidirectional; circular in the horizontal plane. It is independent of the orientation of the horizontal loading wires.

This is NOT a multi-band antenna. While one could feed it with a tuner and open wire line, performance on any band but the one at which the wire length is a half wavelength will not be optimum. Since it's a very good match to 50-ohm coaxial line on the band at which it is a half-wave antenna, it's hard to understand why anyone would want to feed it in any other way.

But, then I'm just an engineer and not a psychologist.

It's important to understand that, no matter how much copper you put into the ground, the only way to get superior performance at low radiation angles is to install a vertical antenna with miles of salt water in the foreground in the direction of the desired propagation. For a good illustration of that fact, take a look at the coverage diagram for WCBS (880 kHz) and WFAN (660 kHz). The antenna for these stations is a single diplexed radiating system located on an island in Long Island Sound. Note how much better the coverage is in directions where there's salt water compared to directions where there isn't much. Your antenna will not be any different.

http://www.radio-locator.com/cgi-bin/pat?call=WCBS&service=AM&status=L&hours=U

Putting a lot of copper into the ground, while, for a grounded quarter-wave may be necessary for the sake of efficiency, will not improve low angle coverage.

It's like feeding a dummy load with a really low-loss transmission line.

I get a lot of correspondence regarding the antenna and the dual-band variant I originally showed for both 160 and 80 meters. I'll show you some variations and I'll try to answer some questions that come up repeatedly. For this discussion, let's talk only about the single 160-meter antenna. I'll leave 80-meter variants and combinations to another article.

Questions regarding the C-shaped (lazy U) configuration:

1. What happens if the top leg is tilted down?

If the top leg slopes downward, the radiation resistance is lower than it would be if the leg were horizontal. You will probably not notice much of an effect until the top wire is tilted down beyond about 30 degrees from horizontal. If, for some reason, the top wire can tilt upwards, the radiation resistance will be a bit higher than it would if flat.

2. What happens if the vertical part is shorter than 70 ft?

As a rule of thumb, the antenna works best if the vertical part is around 1/3 of the total length. That length gives good efficiency and a reasonable match to 50-ohm coax. While, for 160, 90 ft vertical would be ideal, I find that 70 feet is still effective. Less than that works too, but efficiency falls off at less than 50 ft.

The radiation resistance of the antenna (NOT the feed impedance) for a short antenna changes as the square of the length. Therefore, changing the length by a percentage, results in the radiation resistance changing by the square of the percentage. Change the vertical length by 10% and the radiation resistance changes by $(1.1)^2$ or 1.2. A 70-ft 160-meter radiator has a radiation resistance of about 12 ohms. A 50-ft one has a radiation resistance of about 6 ohms.

This antenna, as described, has maximum current flowing at the center of the vertical portion, with small, oppositely-flowing currents in the horizontal legs. The currents in the horizontal legs are nominally in opposition and partially cancel out horizontally-polarized radiation. Current in the vertical section is nearly uniform, tapering to the top and bottom. The shorter the vertical section, the lower the current-length product and the more current there is in the horizontal wires.

3. What happens if the top and bottom wires are not in the same plane (parallel)?

If the top and bottom legs are not parallel, there's an increase in horizontally-polarized radiation and a corresponding decrease in vertically-polarized radiation.

4. If I don't have enough space for the top, bottom or both wires, is it OK for the wires to meander?

Yes. The top and bottom wires are there as a load and have little effect on the radiation pattern. You can turn them at right angles (more than once) in the horizontal plane with no major effects on the antenna other than possible changes in where it resonates. Since cancellation of horizontal radiation is maximum when the wires are parallel, if you have a straight top wire and a meandering bottom wire, you will get a small increase in horizontally-polarized radiation, and the vertically-polarized radiation will be very slightly asymmetrical with a variation of only about a half decibel in the worst case.

The worst case is when the antenna takes the shape of a "Z" with the top and bottom horizontal sections going in opposite directions. That configuration results in the largest degree of horizontally-polarized radiation.

Most of the current in the top and bottom wires is carried in the first third of their length. You should therefore try to keep the bottom and top wires parallel for about a third of the length (about 30 ft or so). After that, they can meander with minimal effects.

5. How high should the bottom wire be?

I put mine high enough so that deer and people don't run into it. It's OK for it to tilt...within reason, just like the top wire. Remember that the far end of the wire is at high rf potential, so it's important to keep it away from ground and things to which an arc might be struck. You don't want to start fires.

6. Do I need a balun

No!

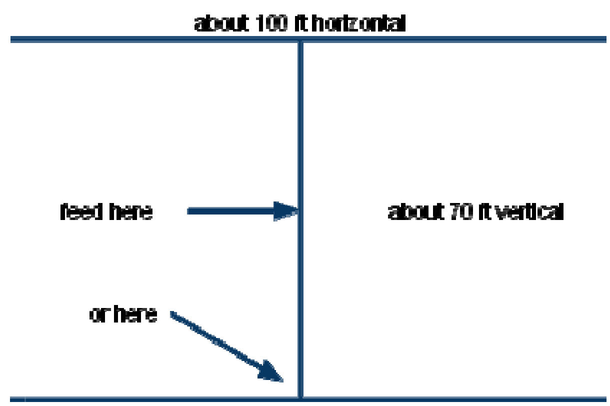
As long as the transmission line isn't close to the ends (which are at high potential) coupling to the outside of the feedline with geometries shown is negligible. Feed it directly with 50-ohm coax. If it makes you feel better, put ferrites on the feedline, but you are just wasting money. If you feed it at the bottom corner instead of at the center of the vertical, you may need to add some isolation, but not if you feed it at the center.

You can also end-feed it as a Zepp (at the end of the lower wire), but that requires a matching network or a tuner of some kind. As long as it's symmetrical, the current maximum is still at the center of the vertical portion. Don't try to make it into a multiband antenna this way.

Keep in mind that this is a shortened vertical that keeps the high-voltage parts of the antenna well away from a center-located feeder. Center feeding a *full-sized*, *straight* half-wave vertical presents a problem that's avoided with the *bent dipole* configuration. One needs to avoid inducing voltage on the outside of the feeder due to proximity of the end of the dipole. That's why full-sized half wave verticals are often end-fed (like the J-pole or Ringo arrangement). That problem does not exist with bent dipoles because the feeder does not pass close to the high-voltage-carrying ends of the antenna.

Keep the feeder away from the ends and run it perpendicular to the plane of the antenna.

Here's a variant that's shaped like a lazy "H" and has no horizontal radiation. The primary reason that I don't use it myself and didn't describe it in the first place is that it's not as simple to erect as the basic Double-L. Typically, it may require three supports, and the performance difference, in my opinion, is not worth the trouble.



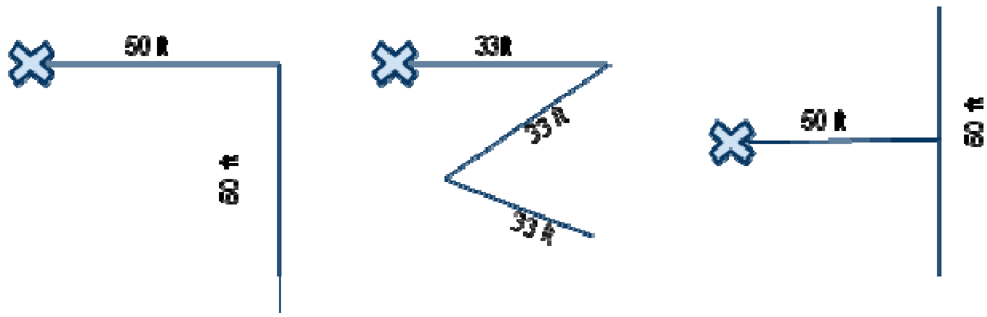
A way to erect this configuration with only two tall supports could use a strong catenary rope to support the top wire, with the rest of the antenna hanging off it with other ropes as needed. An 80-meter version that's about 40 feet high is easily erected this way. A 160-meter version is more challenging.

Of all the correspondence I get on the antenna, the most common problem people encounter is lack of enough space to stretch out the horizontal legs.

Here are a few ways to reduce horizontal extent that work well, with small variations in performance. *These are nominally ways to manage the bottom wire, but what's done about the bottom wire is equally applicable for the top wire.*

If you do not have enough room to stretch the top wire out to 100 feet, stretch it as far as you can and then turn it at right angles, in the horizontal plane. If the turned piece slopes down, it's not the end of the world. Do the best you can.

Here are some horizontal wire variants, shown in the horizontal plane. The vertical radiator runs perpendicular to the page at point X:



Single bend **Double Bend** **Tee End**

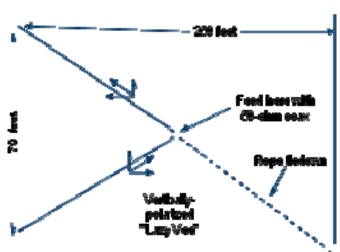
All of these will work. The single bend and the Tee end are especially convenient for the top wire. Lengths are approximate and will require some experimentation to make resonant. Keep the feed line away from the ends, which carry high voltages. You can also use the bottom part of the lazy-H variant (two wires instead of one) with a single top wire. The bottom wires can be bent as in the variants above.

Here's another variation on the basic idea...a half-wave antenna with a simple feed system.

a *lazy-V.*

Everyone is familiar with an inverted Vee, which is predominantly a horizontally-polarized half-wave antenna. A little quick vector analysis shows that the horizontally-polarized currents add and the vertically-polarized currents (mostly) cancel, leaving mostly horizontal polarization.

Imagine now that you turn the inverted vee on its side, rotating it 90 degrees. You now have a vertically-polarized antenna. An advantage of this configuration is that you need only one tall support. The feed point and the top leg can be anchored to the ground (or a short mast).

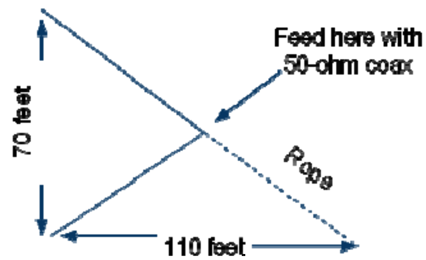


This configuration has been covered by others in the literature...and it works. It needs more room in the horizontal dimension than the lazy-U, but it will work about the same. If you can put up a half-wave "sloper," which has substantial high-angle horizontally-polarized radiation in the plane perpendicular to the wire, you can eliminate the slant polarization by simply running the bottom portion back to base of the main support. As with the previous examples, the fact that the feed point is far from the high voltages at the ends makes a balun unnecessary. Note that the current maximum is at the center of the vertical extent, again making the radiation resistance as high as possible for the height.

The Lazy-V is a neat approach if you only have one tall support. If you can erect a lightweight support at about 30-40 ft. to hold the feed point, you don't need as much horizontal space as for the case where you support the feed point with a rope alone.

Using Loading Coils with a lazy Vee.

This Lazy-Vee arrangement is attractive if you use a loaded dipole, similar to the kind sold commercially by a few suppliers. You can make a good-performing 160M vertical with one high support, a loaded 170 or 135-ft dipole and some rope. Here's an example:



A 135-ft loaded lazy-Vee dipole with one high support

A dipole with loading coils in the wires is more efficient than one might believe. Its primary disadvantage relative to a full-sized dipole is reduced bandwidth.

The long rope to the ground can be truncated if you can support the apex or a point further along the extended top leg with something suitable. If you can get the tensions right, you can use a horizontal rope, tied to a tree or whatever is suitable. A little thought will present other variations that will be apparent to anyone with a little rigging experience.

A combined loaded 160 and full-sized 80-meter antenna can be made this way. A few companies make choke-loaded single or dual-band examples. Drop me an e-mail for a name.

Verticals work well at 160M, are acceptable at 80M and are at a disadvantage to horizontal antennas at 40M and higher due to phase shift in the field reflected from real ground. Phase shift (due to the dielectric constant of the ground) leads to the pseudo-Brewster effect, which, for any ground other than a lot of salt water, kills low-angle radiation.

Try one of these on 160 or 80 meters. It will be worth the small effort involved.

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YCCC Moxon Project

It's my guess that many, many club members have Cushcraft 2-element 40 meter beams, either the old 40-2CD or the XM240 version. (I am one proud owner of the old style). I was wondering if anyone has done the W6NL Moxon conversion? Lee presented a great upgrade at Dayton years back. There are many references on the web – you can get an idea of the mod here:

http://www.k3lr.com/engineering/moxon/W6NL_Moxon104.pdf

This looks like a great improvement to the venerable 'Shorty Forty', with great improvements in efficiency and bandwidth. By my calculations you could get 1 db net gain from the efficiency improvements.

I was wondering if there might be sufficient interest to make it a club project. Group parts buy, etc.

If you have serious interest, email me at barockteer@aol.com. I'll make a list. (Not volunteering to be project manager; got plenty to do in my new job)!

Tony, K1KP