# An Improved Double Extended Zepp

By Rudy Severns, N6LF
32857 Fox Lane
PO Box 589
Cottage Grove, OR 97424

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*N6LF revisits the classic double extended Zepp to improve pattern and SWR bandwidth. He also offers some sage advice about computer modeling.*

The sunspot cycle is headed down and the low bands are coming to life for DXing. The next several years will be the time to make those low-band contacts for DXCC. As always, the key to low-band operation is a good antenna. Unfortunately for 7 MHz and down, good antennas don't come in a box ready to assemble. Every location will have a unique set of limitations and opportunities.

One very important difference between this sunspot minima and all past ones is the availability of inexpensive, easy-to-use and powerful antenna modeling software.[1,2] This software allows you to design and optimize an antenna that exactly fits your situation and pocketbook. While cut-and-try experimentation is a very slow way to optimize antennas, modeling is so quick that a wide range of solutions can be investigated easily. The real problem with modeling is generating the will power to stop fooling with the variations and go out and build something!

The following article uses 40 and 80/75-meter double extended Zepps (DEZepp) as examples of what you can accomplish. By adding two small capacitors, made from short lengths of RG-8, in just the right place, the pattern can be improved and the driving-point impedance changed from reactive and narrowband to resistive and wideband. This allows the antenna to be used without a tuner and with an SWR < 1.5:1 over the entire 40-meter band, or with SWR < 2:1 over the entire 75/80-meter band.

### A Look at the Classical DEZepp

The classical DEZepp is simply a piece of wire 1.25 λ long, fed at the center, usually with open-wire transmission line and a tuner at the transmitter. The DEZepp displays a useful amount of gain over a dipole of approximately 3 dB. The radiation pattern for a DEZepp designed for 7.15 MHz and suspended 80 feet above ground is shown in **Fig 1**, along with the pattern for a λ/2 dipole at the same height for comparison. The elevation angle is 26°, the peak of the main lobe. The current distribution along the antenna is shown in **Fig 2**.

The DEZepp does indeed provide gain over the dipole, but only over the relatively small angle of approximately 40°. The beamwidth between 3 dB points is 35°. Unless the antenna is pointed directly toward the receiving station, the gain is not usable due to the narrow beam width. In addition to the narrow main lobe, there are significant sidelobes. These are not big enough to be helpful in those directions, but they will also certainly pick up noise and interference. The impedance of the antenna is very reactive, and even when matched at midband does not allow the entire band to be covered without retuning.

For this reason, the DEZepp has traditionally been used with an antenna tuner. This is

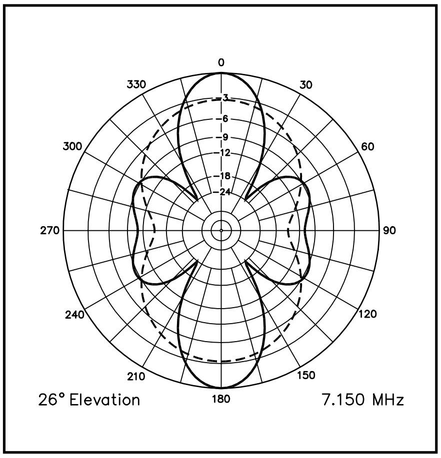


Fig 1—Azimuth pattern of classic double extended Zepp (solid line) at 7.15 MHz, compared with standard dipole (dashed line), both 80 feet high over average ground. Patterns are shown at 26° elevation, where the gain is maximum. The wire runs along the 270° to 90° axis on the graph. Note significant sidelobes for DEZepp.

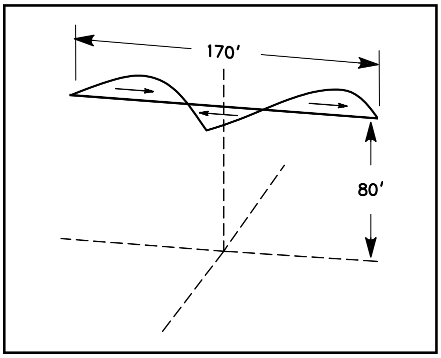


Fig 2—Schematic for classic DEZepp, showing current distribution along antenna. The "bulging out" of the current in the opposite direction near the center of the antenna is responsible for the sidelobes seen in Fig 1.

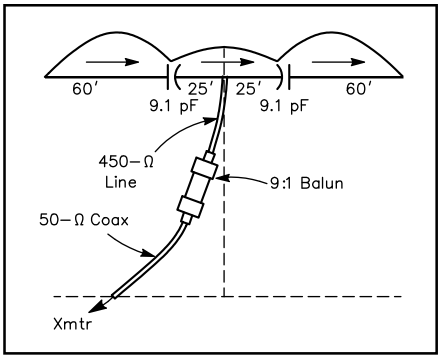


Fig 3—Schematic for modified N6LF DEZepp, with new current distribution. Overall length is 170 feet, with 9.1 pF capacitors placed 25 feet each side of center. Now current distribution doesn't create sidelobes.

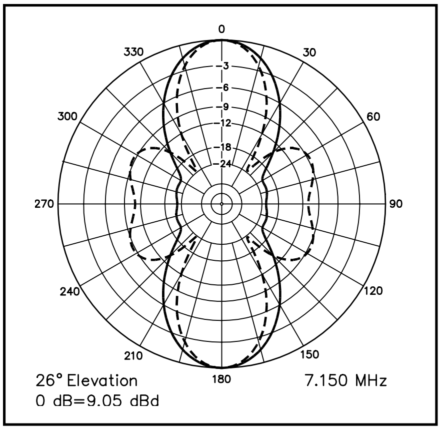


Fig 4—Azimuth pattern for N6LF DEZepp (solid line), compared to classic DEZepp (dashed line). The main lobe for the modified antenna is slightly broader than that of the classic model, and the sidelobes are suppressed better.

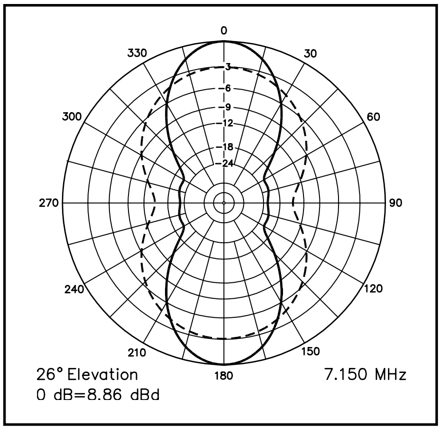


Fig 5—Azimuth pattern for N6LF DEZepp (solid line), compared to dipole (dashed line) at the same height.

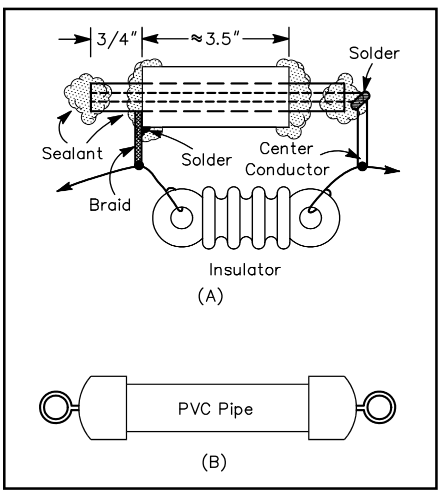


Fig 6—Construction details for series capacitor made from RG-213 coaxial cable. At A, the method used by N6LF is illustrated. At B, a suggested method to seal capacitor better against weather is shown, using a section of PVC pipe with end caps.

not a terrible hardship but it would be nice if the tuner could be eliminated, at least on one band, and a low SWR presented to the transmitter over a whole band.

The gain displayed by the DEZepp is due to the separation between the two current maxima. The small inverted current in the center section subtracts a little from the main lobe and contributes to the sidelobes. The DEZepp is essentially two end-fed collinear dipoles. The transmission line and the center portion of the antenna are the feed system.

It would be very beneficial to suppress the sidelobes and put that energy into a broader main lobe, retaining most of the gain if possible.

### A Modified DEZepp

The key to modifying the radiation pattern is to modify the current distribution. One of the simplest ways to do this is to insert a reactance(s) in series with the wire. This could either be an inductor(s) or a capacitor(s). In general, a series capacitor will have a higher Q and therefore less loss. With either choice it is desirable to use as few components as possible.

As an initial trial I decided to use only two capacitors, one on each side of the antenna. I varied the value and position of the capacitors to see what would happen. It quickly became clear that I could tune out the reactance at the feedpoint by adjusting the capacitor value, making the antenna look like a resistor over the entire band. The value of the feed-point resistance could be varied from less than 150 Ω to over 1500 Ω by changing the location of the capacitors and adjusting their values to resonate the antenna. The *AO 6* (Antenna Optimizer) software[1] has the nice feature that it will automatically adjust a variable to tune out reactance. Simultaneously, the pattern was also changing in useful ways.

A number of interesting combinations were created. The one I elected to use is shown in **Fig 3**. The antenna is 170 feet in length. That is a couple of feet shorter than the classic DEZepp, but that also just happens to be all the distance I had between my supporting trees! Two 9.1 pF capacitors are located 25 feet out each side of the center. The antenna is fed with 450-Ω transmission line and a 9:1 three-core Guanella balun[3] used at the transmitter to convert to 50 Ω. The transmission line can be any convenient length and it operates with a very low SWR.

That's all there is to it. The radiation pattern, overlaid with that for a standard DEZepp for comparison, is shown in **Fig 4**. A comparison to a standard dipole is shown in **Fig 5**. The sidelobes are now reduced to below 20 dB. The main lobe is now 43° wide at the 3-dB points, as opposed to 35° for the original DEZepp. The antenna has gain over a dipole for > 50° now. The gain of the main lobe has dropped only 0.2 dB below the original DEZepp.

The reason for the pattern change can be seen in Fig 3, showing the modified current distribution. The main current maxima are still pretty much in the same place, but the current in the center of the antenna now flows in the opposite direction. The resulting pattern is much cleaner.

### Experimental Results

I managed to pry myself away from the computer and actually build the antenna. It was made from #14 wire and the capacitors were made from 3.5-inch sections of RG-213, shown in **Fig 6A**. Note that great care should be taken to seal out moisture in these capacitors. The voltage across the capacitor for 1.5 kW will be about 2000 V so any corona will quickly destroy the capacitor. One of the nice features of modeling software is that it gives the current amplitude along the antenna, making it easy to determine the stresses on any series reactances.

I used silicon sealant and then covered both ends with coax seal, finally wrapping it with plastic tape. The solder balls indicated on the drawing are to prevent wicking of moisture through the braid and the stranded center conductor. This is a small but important point if long service out in the weather is expected. An even better way to protect the capacitor would be to enclose it in a short piece of PVC pipe with end caps, as shown in Fig 6B.

Note that all RG-8 type cables do not have exactly the same capacitance per foot and there will also be some end effect adding to the capacitance. I trimmed the capacitor with a capacitance meter. It isn't necessary to be too exact—I checked the effect of varying the capacitance ±10% and the antenna still works fine.

The results proved to be close to those predicted by the computer model. **Fig 7** shows the measured value for SWR across the band. These measurements were made with a Bird directional wattmeter. The worst SWR is 1.35:1 at the low end of the band! With a little adjustment of the antenna length this could have been lowered a bit more, but I figured why bother?

My antenna was oriented to work into Europe. Prior to putting up this antenna I had been using a dipole. I could hear a few Europeans but was unable to work them. Three dB may not seem like much gain but after putting up this antenna I immediately heard many more signals and have been regularly working into Europe with 56/57 reports.

Dick Ives, W7ISV, was sufficiently impressed by the success of the 40-meter version of this antenna to ask me to design a 75-meter version for him. In his location one end of the antenna could only be 60 feet high ($< 0.25\ \lambda$), and I was concerned about the accuracy of the modeling program, because *MININEC*-based programs are known to be inaccurate for gain and feed-point impedance at low heights. Fortunately, Brian Beezley, K6STI, has a *NEC*-based program called *NEC Wires.*[1] This does model ground accurately and is just the ticket for low antennas. Using this program I designed a new antenna for W7ISV.

Despite the temperatures in mid-December, Dick erected the antenna as shown in **Fig 8**. The series capacitors are 17 pF, and since he isn't interested in CW, Dick adjusted the length for the lowest SWR at the high end of the band. The antenna could have been tuned somewhat lower in frequency and would then provide an SWR < 2:1 over the entire band, as indicated by the dashed line in Fig 8.

This antenna provides wide bandwidth and moderate gain over the entire 75/80-meter band. Not many antennas will give you that with a simple wire structure.

### Multiband Operation

When operated with an antenna tuner, one of the advantages of the classical DEZepp is that it is a multiband antenna. Typically a 40-meter DEZepp behaves like a dipole on 75/80 meters and like a long wire on the higher frequency bands. Adding the two series capacitors decouples the ends of the wires on 75/80 meters and a rather poor antenna results. It behaves more like a 30-meter dipole being used on 75/80 meters. For the bands above 40 meters, however, the reactance of the capacitors drops rapidly and the behavior is very much the same as for the normal DEZepp. The price paid for improving operation on 40 meters is the loss of 75/80 meters. Similarly, in the 75/80-meter version, performance on 160 meters is sacrificed.

### Some Final Thoughts

The antenna shown here represents a very simple modification of an old idea to suit a particular situation. There are any number of variations that could have produced similar results. Two important lessons were learned during this effort. First, the modeling software is pretty accurate, particularly now that *NEC*-based software is available. The results obtained were very close to that predicted—and this is not the first time I have seen this. Second, the modeling process is a great teacher. It helps you to learn how antennas really work and cuts through many misconceptions. By viewing the current distributions, the associated radiation patterns and driving-point impedances, it becomes much easier to understand which way to modify a design to achieve a desired result. Being able to get results quickly is very helpful also.

There is a whole new world of low-band antennas out there waiting to be created!


### Acknowledgments

I want to express my appreciation to Dick Ives for braving the wet and cold to verify the 75/80-meter version of this antenna in time for me to add it to this article. Brian Beezley was very helpful with comments on the design, and of course he created the new *NEC Wires* program. An antenna is only as good as the materials that go into it. I used the beautiful "silky" stranded copper-clad steel wire supplied by Press Jones, N8UG, and also some of his 450-Ω transmission line. It was wonderful to have a wire antenna that didn't try to envelop you (and every nearby bush) like a boa constrictor due to a built-in set in the wire.


### Notes

[1]*AO 6.1* and *NEC Wires*, by Brian Beezley, K6STI, 3532 Linda Vista Dr, San Marcos, CA 92069.

[2]*ELNEC 3.0*, by Roy Lewallen, W7EL, PO Box 6658, Beaverton, OR 97007.

[3]Jerry Sevick, W2FMI, *Transmission Line Transformers*, Second Edition (ARRL, Newington, CT, 1990), p 9-28.

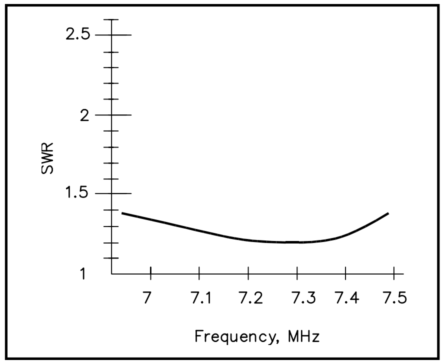


Fig 7—Measured SWR curve across 40-meter band for N6LF DEZepp.

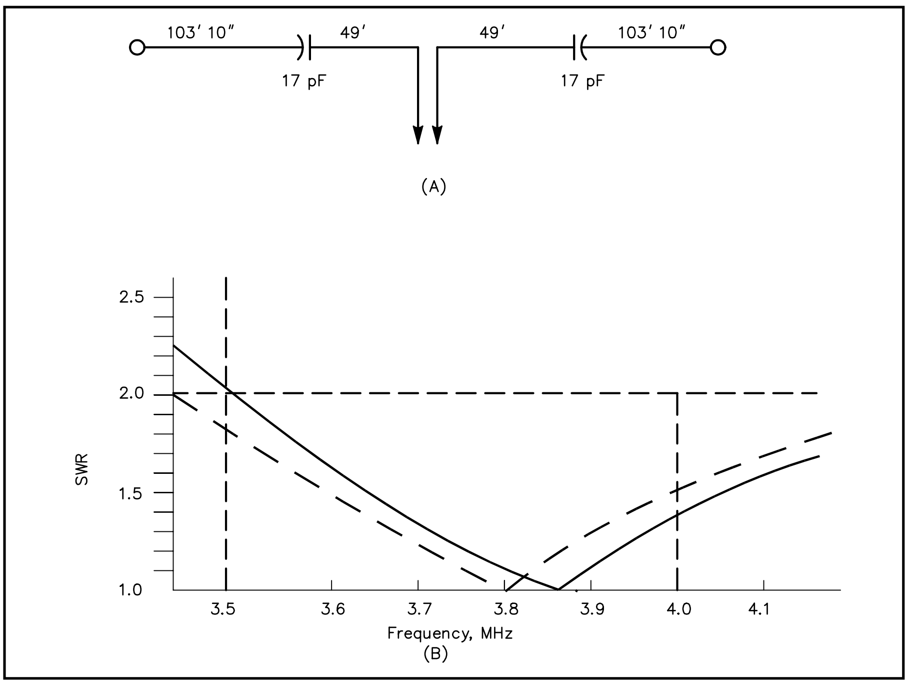


Fig 8—75/80-meter N6LF DEZepp, designed using *NEC Wires*. At A, a schematic is shown for antenna. At B, SWR curve is shown across 75/80-meter band. Solid line shows measured curve for W7ISV antenna, which was pruned to place SWR minimum higher in the band. The dashed curve shows the computed response when SWR minimum is set to 3.8 MHz.