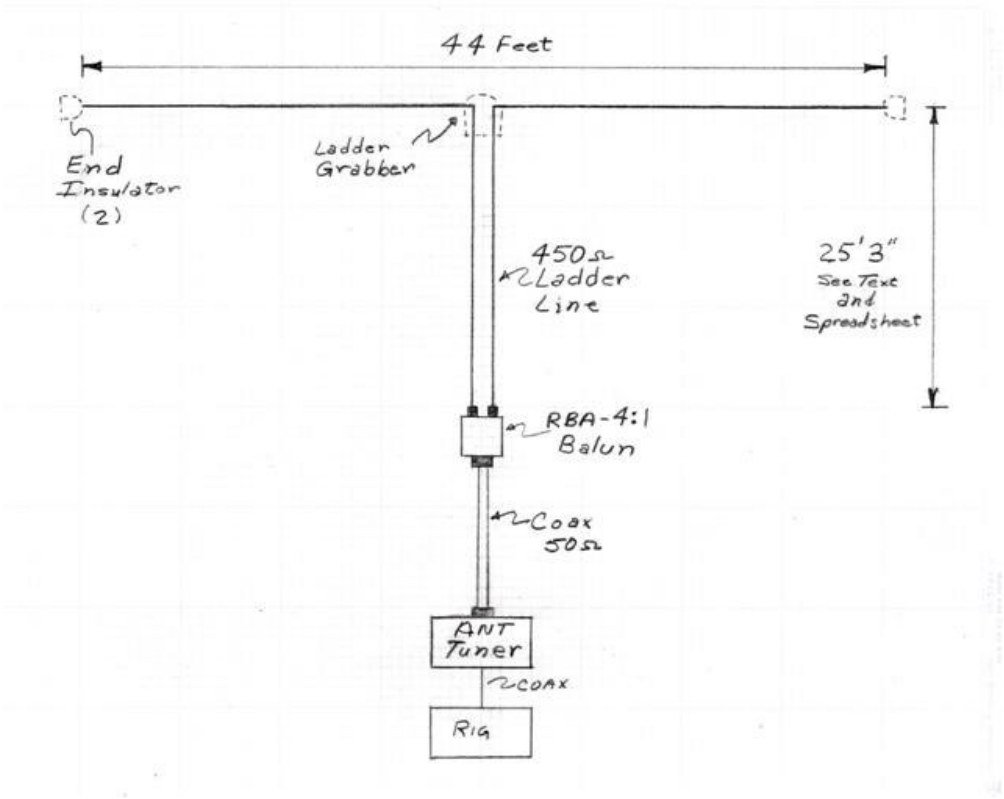
A 44 Foot Extended Double Zepp for 40 Through 10 Meters

The basics of this simple, short, non-resonant, multiband antenna was brought to my attention by L. B. Cebik W4RNL [SK] in the original posting on his web site. The article "Suppose I Could Have Only One Wire Antenna" was originally put on the site in 2000 and is still available with various updates as [Currently a login from AntenneX is required to view material]:

> Suppose I Could Have Only One Wire Antenna. . . (03-21-2003)
> Updated 03-01-2000, 07-01-2002, 03-26-2003, 07-30-2003. © L. B. Cebik, W4RNL.
> This item appeared in AntenneX, February, 2000.
> http://www.cebik.com/content/edz/aledz.html
> and is also covered in:
> My Top 5 Backyard Multi-Band Antennas (08-11-2004) (PDF)
> http://www.cebik.com/content/fdim/fdim9.pdf

Cebik provides considerable analysis of the antenna and its characteristics in his papers and is well worth the reading if you are interested in considerably more detail.

Below is the basic configuration of my antenna.

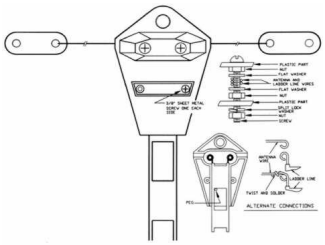


The most significant difference in my installation is the antenna height of approximately 25 feet instead of 66 feet. This significantly changes the feed point impedance at the center of the doublet. In either case finding a method of feeding the wire on multiple bands is the most prominent challenge to overcome. First I will deal with the materials used in constructing the antenna.

Materials List:

100' of FlexWeave Antenna Wire FW14B-100 14 gauge 100 ft [Universal Radio #4608]

This ultra-flexible 14 gauge stranded copper antenna wire will not kink or tangle. Can be tied and untied to insulators without soldering. It actually feels more like wire rope than wire!

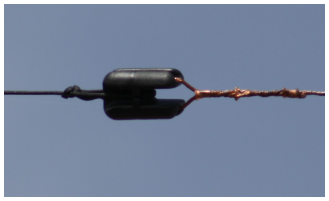


Ladder Grabber
http://emtech.steadynet.com/lgrabber.shtml

I found my Grabber at a local hamfest.

Gardner Bender Copper Crimp Sleeve Connectors #10-310C
http://www.gardnerbender.com/products/wire_connectors.html

I bought 100 at LOWES – The correct part is the small one.
12 are needed to hold the wire. Use 3 at each wire end.



2 End Insulators, also found at local Hamfest
Could have used the Ladder Grabber parts, but I liked these new egg style instead.

LDG RBA-4:1 Bauln [200 Ohm :50 Ohm]

This unit is rated to 200 Watts, If you run high power a higher power Bauln will be required.

450 Ohm Ladder Line, 18 gauge 0.75 inch spacing about 30 feet

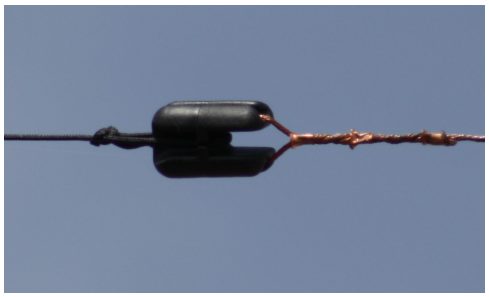
Parachute cord or other support line from vertical end supports.

Some means of support for the Ladder Graber / ladder line.

50 Ohm Cable RG8X or better.

Construction:

The most important point in constructing any Doublet antenna is to keep the wire length on each side of center equal in length. With this particular antenna the 44 foot length is not overly critical, so just make sure the two wires are exactly the same length.



I first passed each antenna wire through the end insulator and wrapped about 3 inches of the wire tightly back on itself. Then I crimped 3 of the copper crimp sleeves over the wrap. [see picture at left]

Next, measure 22 feet from the farthest end of the insulator loop and place a marker on each wire, leaving about 6 inches of wire beyond the mark to attach to the Ladder Grabber and the ladder line. Also place 3 of the copper crimp sleeves on each wire before assembling the ends to the Ladder Grabber or your chosen center insulator.

Prepare one end of the ladder line by removing at least 3 inches of insulation from each side of the line. The Grabber instructions show how to assemble the line and the hardware. I will cover the length of the ladder line in the next section.

At the center insulator / Ladder Grabber end of the wire make sure the mark on the wire is centered behind the screw and then make a wrap around and twist the antenna wire with one end of the ladder line back around the antenna wire, before crimping on any of the crimp sleeves. It is best to completely assemble the Ladder Grabber before crimping any of the sleeves. Trim any excess wires as well before crimping.

To the left are photos of my support which is made from PVC pipe and clamped to a metal mast.

The straight sections are electrical grade ½" PVC. The T's ,L's and caps are plumbing fittings that have been painted grey for uv resistance.

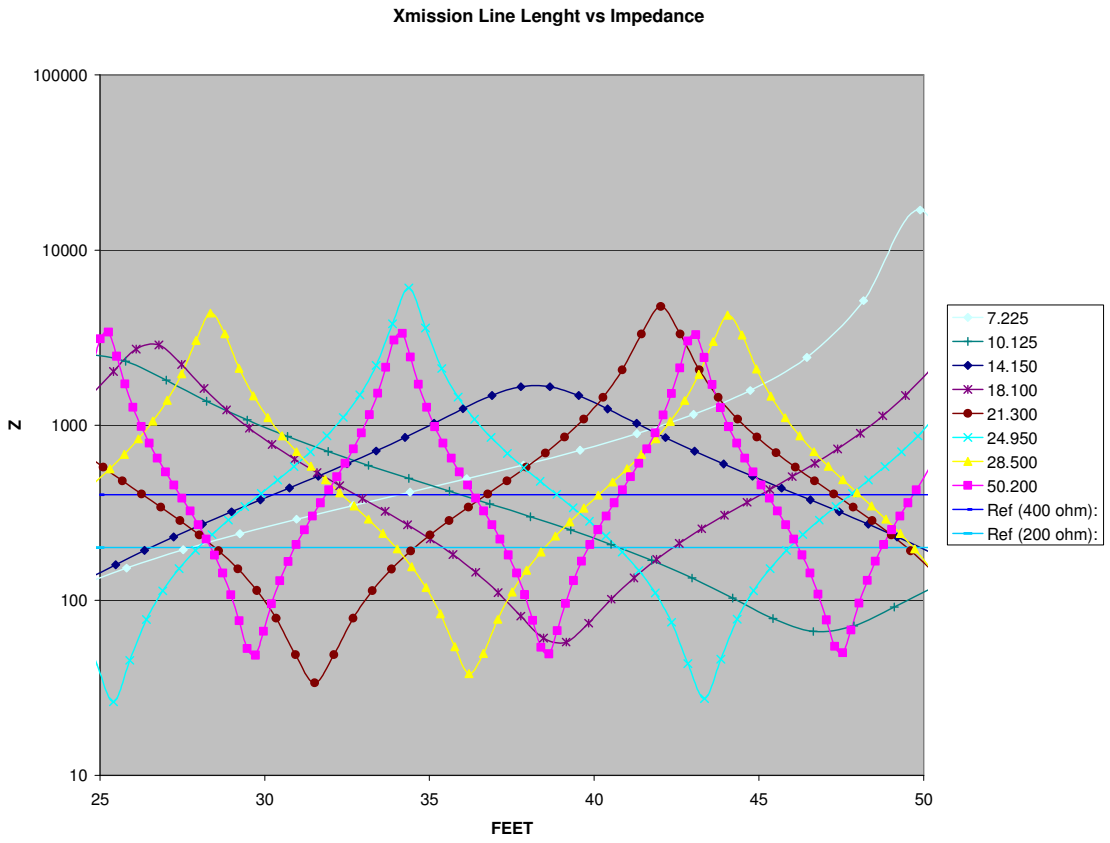
The horizontal leg is 4'.

Feeding the Antenna:

As I have mentioned feeding the antenna is the major problem with this design. I have also read several comments that it is impossible to match to your rig under any circumstance. I use EZNEC+ v4 for simulation and the antenna at Cebik's 66' or my 25' provides a wide array of impedances to challenge a simple solution.

To aid me in my quest for an answer, I put the entire transmission line equation into an Excel spread sheet and used the graphing capabilities of Excel to simplify the solution. Any transmission line will act as an impedance transformer and all that is needed is to pick the correct length and the impedance at the doublet will be transformed to another at the other end. My first look at 50 Ohms [to achieve a 2:1 SWR or less] did not appear to have any practical solution. The only possible approach would involve switching in and out various lengths of 450 Ohm ladder line to achieve a reasonable SWR solution.

Later I decided to look at a 200 Ohm solution, which yielded a possible line length of about 26' 3". The expanded Excel plot of Z [complex impedance] from 25' to 50' is shown below]. A second length of about 28' also looked promising for 5 bands.



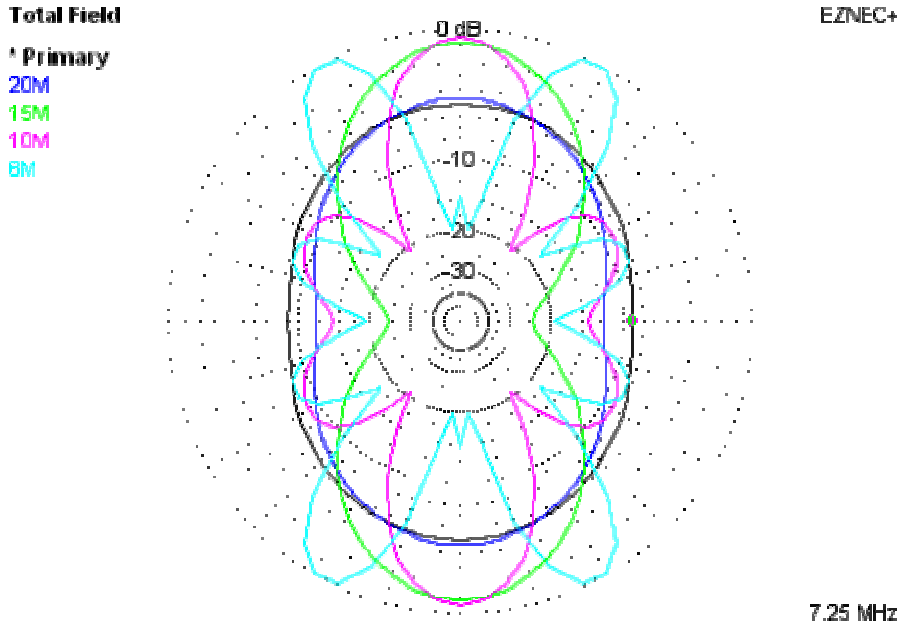
When I constructed my antenna I had over 30' of 450 line attached to the antenna and planed to measure and trim to see what the results would be. Unfortunately [for me] I inadvertently cut the line at 25'3". The data that follows is for that length. I now plan to add some lengths when time permits, but I have been satisfied with the current length.

44 Foot EDZ approx 22 foot in air fed with 25' 3" 450 ohm open line to 4:1 Balun
Readings made with an Autek Research RF1 RF Analyst after 4:1 Balun

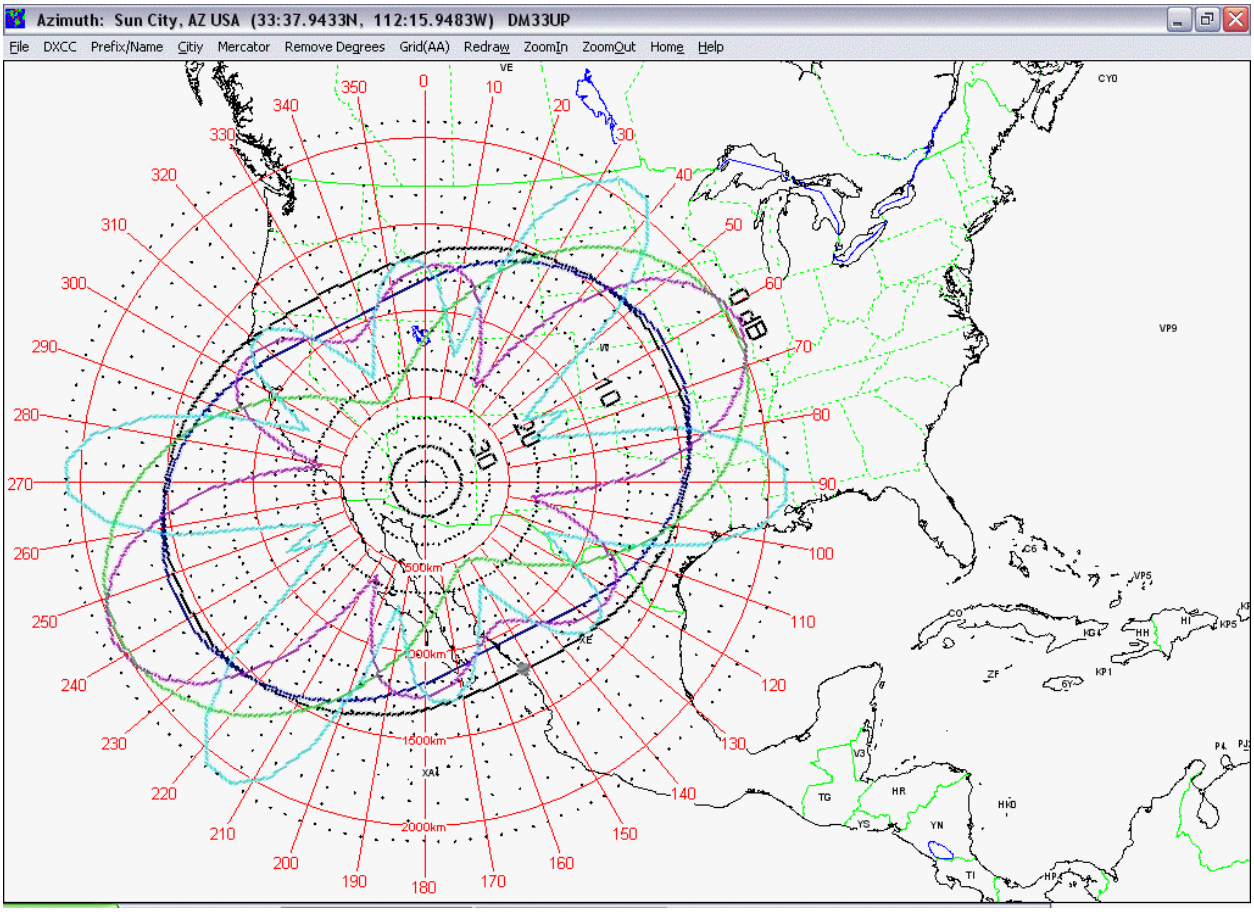
		Direct Connection		114" of RG8X	
Approximate					
Frequency		**SWR**	**Z**	**SWR**	**Z**
7.159 MHz		17.2	48	16.2	230
10.110 MHz		6.9	325	6.9	34
14.070 MHz		4.1	72	3.26	60
14.200 MHz		4.3	78	3.43	55
14.400 MHz		4.7	89	4.2	-
18.100 MHz		8.5	294	3.92	17
21.210 MHz		4.4	54	5.3	98
21.400 MHz		4.7	49	5.2	119
24.900 MHz		3.58	30	4.9	16
28.290 MHz		7	270	3.78	75
28.530 MHz		5.6	256	3.93	86
29.080 MHz		4	197	3.32	124

Antenna Patterns:

Cebik in his articles presents a complete discussion and more plots.



This has the previous plot centered in Sun City, AZ and orientated as my antenna.



The Azimuth program used above is available from Tony Field VE6YP at his website :
http://hamradio.lakki.iki.fi/new/Software/Radio%20control/radio_control_and_logging/
or http://hamradio.lakki.iki.fi/new/Software/Radio%20control/radio_control_and_logging/azimuth3.zip

EZNEC+ is available from Roy Lewallen W6EL at http://www.eznec.com/

A copy of my spreadsheet "XLA4-450-EDZ-200ohm-14ga.xls" along with the EZNEC file and a copy of this presentation is available on my website:
http://members.cox.net/k9ivb in zip file 44ft_EDZ_Ant_Details.zip.

Appendix:

A complete discussion of how to implement the Excel spread sheet to solve the Transmission Line Equation is beyond what can be covered in this short presentation. The equation presented below can be found in any issue of the Radio Amateur Antenna Handbook or any University level textbook on Transmission Line Theory. The difficult part is finding all of the properties of actual transmission lines in the correct numerical format to enter into the equation.

Excel is an outstanding platform to solve complex and imaginary mathematical equations [as in r +jx] with very nice graphing capabilities. It is necessary to have the add-ins for math installed for the complex operators to function correctly.
In this case the graphs are worth millions of calculations in determining a solution to the problem.

Excel requires the trigonometry identity used in eq 2 as there are no cosh functions in Excel. The solution also is the same as using a Smith Chart because the Smith Chart is using the same equation in polar form. The Excel spread sheet is just a brute force solution to the equation and this approach will work in any version of Excel from Office 97 through Office 2010. The equation can also be solved in a more elegant fashion if one uses the VBA feature in Excel but security issues keep many from configuring the program to use the "macro" function.

Transmission Line Equations

$$\lambda_{feet} = \frac{983.5592}{f\,(MHz)} \quad \text{or} \quad \lambda_{meters} = \frac{299.7925\ x\,10^6\ (meters/\sec)}{f\ (Hertz)} \qquad \text{(eq. 1)}$$

$$Z_{in} = Z_0 \frac{Z_L \cosh(\gamma\ell) + Z_0 \sinh(\gamma\ell)}{Z_L \sinh(\gamma\ell) + Z_0 \cosh(\gamma\ell)} \qquad \text{(eq 2)}$$

$$Z_{in} = Z_0 \frac{Z_L\left(\frac{e^{\gamma\ell} + e^{-\gamma\ell}}{2}\right) + Z_0\left(\frac{e^{\gamma\ell} - e^{-\gamma\ell}}{2}\right)}{Z_L\left(\frac{e^{\gamma\ell} - e^{-\gamma\ell}}{2}\right) + Z_0\left(\frac{e^{\gamma\ell} + e^{-\gamma\ell}}{2}\right)} \qquad \text{(Form used in Excel) (eq 2a)}$$

Where:

Z_{in} = complex impedance at input of line
Z_L = complex load impedance at end of line = $R_a \pm j X_a$
Z_0 = characteristic impedance of line = $R_0 \pm j X_0$
ℓ = physical length of line
γ = **complex** loss coefficient = $\alpha + j\beta$
α = matched-line loss attenuation constant, in nepers/unit length (1 neper = 8.688 dB; cables are rated in dB/100 ft)
β = phase constant of line in radians/unit length (related to physical length of line ℓ by the fact that 2π radians = one wavelength (λ), and by eq 1)

$$\beta = \frac{2\pi}{VF\ x\ 983.5592 \big/ f\ (MHz)} \quad \text{for } \ell \text{ in feet}$$

VF = Velocity Factor $= \frac{1}{\sqrt{\varepsilon}}$ where ε is the dielectric constant of the line material (air = 1)

ℓ = electrical length of line in same units of length measurement (feet) as α or β above