

Multiband Vertical Antenna Project

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Purpose

If you could only have *two* antennas, what would they be?

It has been observed that the 160-meter horizontal dipole (and full-wave loop), fed with ladder line and a tuner, provide excellent multiband performance. However, on 20 meters and above, the large horizontals present an azimuth pattern with many deep nulls. It is essentially an NVIS (regional low-bands) antenna, and unsuitable for DX work.

The purpose of this project is to design a simple multiband vertical dipole antenna for 20 meters and above, with a tuner, that will provide gain and a circular pattern on the higher bands. It will supplement the big horizontal dipole by providing good omnidirectional coverage, with some gain, from 20 through 6 meters. It will be physically designed as an experimental assembly, so that it may be adjusted in the field for a variety of experiments and other purposes.

Electrical Design

The hardware may be assembled into several different designs. This first experiment will be a center-fed dipole. This design will provide 1-4 dbi gain and a low angle of radiation (under 20 degrees predicted) without any need for ground plane or matching systems. Modeling was performed on a vertical dipole, with elements tapered, over average ground, using MMANA. The antenna will be useable from 20 through 6 meters with gain and a circular pattern. It will be center-fed with ladder line and an antenna tuner with internal balun. This will greatly reduce feedline losses. If coax is used, expect 50 to 75 percent feedline loss (unacceptable).

Initial design parameters:

- Resonant frequency: 14.175 MHz
- Length overall 33.5 feet (402 inches, 10.2 meters)
- Feed: Split-center using PVC pipe; 1.25 inch handmade ladder line, to ATU in shack
- Expected SWR fed with 1.25-inch ladder line: 5:1 at 20 meters; between 3:1 and 4:1 on higher

bands (nine times higher with coax)

- Expected gain (dbi): 1.0 at resonance, rising to 4.3 at 29 MHz (higher if antenna elevated)
- Expected elevation angle at 20 meters: 19 degrees, lowering to 12 degrees at 10 meters (lower if antenna elevated)
- For the only known treatise on this design, see <http://www.cebik.com/v20.html>

Physical Design

The use of 7 six-foot sections of 0.058 slip-fit aluminum tubing will allow easy adjustment of the feedpoint (and overall length) by varying the overlap of tubing sections. Tube ends will be slotted and clamped with SS hose clamps (not drilled).

The feedpoint insulator will be 2 feet of 1-inch Schedule 40 PVC, which will be heated and formed to slip-fit outside of sections 4 (1.125") and 5 (1"). This has an ID 1.049. The lower half of the insulator will be heated and forced over section 4; the upper half heated and swaged down to section 5 (apply 2 hose clamps while pliable). The center of the insulator will be slotted 3/8 x 2 inches with a router to provide feedline connection. A sleeve of 1¼-inch schedule 40 (ID 1.380) will then be slotted, heated, and slipped over the termination point to add strength.

The base insulator should be 10 feet of 1½-inch schedule 80 PVC pipe, which has an ID of 1.500 inches. The base of the antenna should be raised at least 8 feet to prevent RF burns. If schedule 80 is not available, schedule 40 may be used by heating and swaging down with hose clamps. However, raising the antenna without breaking schedule 40 may be tricky.

The antenna will be guyed with 3 lines of #36 nylon mason's line. These will attach just above the center insulator and slope outward at a reasonable angle to trees or driven stakes. For hurricane duty, the guys should be ¼-inch nylon, tied to driven 1-inch (by 48") galvanized steel pipe stakes. One guy line must be opposed to the feed line so that it may be pulled taut. The feedline should run horizontal for 40 feet or more.

Data and Materials Tables

O.D.	WALL	I.D.	LBS./FT.	\$/FT.
6063-T832 DRAWN ALUMINUM TUBING				
.375"	.058"	.259"	.044	\$0.70
.500"	.058"	.384"	.095	\$0.80
.625"	.058"	.509"	.104	\$0.90
.750"	.058"	.634"	.127	\$1.00
.875"	.058"	.759"	.150	\$1.10
1.000"	.058"	.884"	.202	\$1.20
1.125"	.058"	1.009"	.229	\$1.35
1.250"	.058"	1.134"	.255	\$1.55
1.375"	.058"	1.259"	.283	\$1.75
1.500"	.058"	1.384"	.309	\$1.95
1.625"	.058"	1.509"	.336	\$2.25
1.750"	.058"	1.634"	.363	\$2.50
1.875"	.058"	1.759"	.384	\$2.75
2.000"	.058"	1.884"	.416	\$3.00
2.125"	.058"	2.009"	.443	\$3.50
6061-T6 EXTRUDED ALUMINUM TUBING				
.188"	SOLID	SOLID	.032	\$.25
.250"	SOLID	SOLID	.058	\$.45
1.125"	.058"	1.009"	.229	\$1.10
1.250"	.058"	1.134"	.255	\$1.25
2.000"	.120"	1.760"	.833	\$4.50
2.000"	.250"	1.500"	1.616	\$8.00
6061-T6 EXTRUDED BAR STOCK				
4.000"	.375"	SOLID	1.8	\$6.50

Table 1: Texas Towers Aluminum

from <http://www.texastowers.com/aluminum.htm>

6063-T832 in 6-foot sections:

Sec.	Size	/ft	#Ft.	Cost
8	0.625	0.90	6	5.40
7	0.750	1.00	6	6.00
6	0.875	1.10	6	6.60
5	1.000	1.20	6	7.20
4	1.125	1.35	6	8.10
3	1.250	1.55	6	9.30
2	1.375	1.75	6	10.50
1	1.500	1.95	6	11.70
Base Total				\$64.80
Delivered + Texas Tax				\$87.09

Table 2: Aluminum Materials

Note: Section 8 not used in this project.

Note: Sections 1-4 are the lower element; sections 5-7 are the upper element. May be made with only six sections but lower element will not be as strong.

Description	OD	ID	/ft	Quant.	Cost
1½" Sch-80 PVC Base Insulator www.usplastic.com	1.900	1.500	1.27	10'	12.70
1" Sch 40 Center Insulator	1.315	1.049		2'	
1¼" Sch-40 Reinforc. Sleeve	1.660	1.380		1½'	
2" SS Worm Gear Hose Clamp				2	
1¾" SS Worm Gear Hose Clamp				2	
1½" SS Worm Gear Hose Clamp				4	
1¼" SS Worm Gear Hose Clamp				4	
1" SS Worm Gear Hose Clamp				4	
Misc sheet metal screws				2	
1¼" homemade ladder line, #14 AWG				40-80'	
Ring Lugs, #8 hole				2	
Silicone spray can				1	
Aluminum anti-corrosive (Penetrox)				1	

Table 3: Other Materials

Overall Cost

This antenna may be constructed for about \$100.

Construction Notes

The lower element uses 4 sections, overlapped about 29 inches, for strength. The upper element uses 3 sections, overlapped about 6½ inches, for low weight. Sections are slotted and clamped with worm gear hose clamps. Use Penetrox at every joint and at the feedline connection.

Design	Freq	E _L In	E _L Const	E _U In	E _U Const	LOA ft or in	LOA Const	OCF % (+ = up)
20-meter OCF Sleeve Dipole monobander with coax feed	14.175	235"	+34"	167"	-34"	33.5' 402"	474.8 5697.6	+8.5% (of loa)
20-10 Multiband CF Doublet w/ 450-ohm ladder line	14-29	201"	+0"	201"	-0"	33.5' 402"	474.8 5698	0%
40-Meter ¼-wave Vertical	7.150					33.2' 398.4"	237.4 2848.8	--
60-Meter ¼-wave Vertical	5.3665					44.23' 530.8"	237.4 2848.8	--

Table 4: Assembly Dimensions (approximate, initial calculated)

Analysis

MMANA optimization shows a constant of 474 (not 468) using 14.175 MHz and actual section radii.

For multiband use, MMANA shows the best feedline to be 450-ohm ladder, side-fed, which will produce a wide SWR curve from 14 to 29 MHz, between 5:1 and 3:1, respectively. Ladderline will handle 5:1 SWR easily with no appreciable loss. Fed in this manner, the gain will be about 1.0 at 14, rising to 4.3 dbi at 29 MHz. Will be even higher on 50 and 144 (up to 7 dbi gain, but at 45 degrees).

Elevation angles: 2 and 6: 45 degrees; 10: 12 degrees; 15: 15 degrees; 17:16 degrees; and 20: 18 degrees.

Conclusion: The 20-meter vertical dipole, center-fed with 450-ohm ladder, will be a good-performing and inexpensive 20- through 10-meter omnidirectional antenna, used with a tuner and current balun at the tuner. Also useable on 6 and 2, but high radiation angle will limit performance. The line should run horizontal for 40 feet or more.

Constructed as an off-center-fed sleeve dipole, coax will run up to the feedpoint inside the lower element. Since the coax will interact with the lower element, the feedpoint must be moved off-center to locate the lowest SWR. Exact measurements are yet to be determined, but a 2-meter version has a flat SWR (50 ohm) when offset 8.5 percent of overall length (see kv5r.com/articles/ham/sleevedipole.asp).

Results

Tests based on S-meter readings on an Icom IC-706MkIIIG. Gain figures are db compared to my 160-meter horizontal dipole. Each antenna was matched with the tuner (MFJ 949E). A variety of signals were measured on each band, and averaged.

Band	Gain	Note
40	Considerably less	As expected
30	About the same	As expected
20	+6	
17	+9 to 12	
15	+6 to 9	Much quieter
12	+6	
10	+12 to 18	

Table 5: On-air Results

The location contains many large trees within 20 to 30 feet, and two metal structures within 30 feet. Placement in an open area would undoubtedly provide better results.

The ½-wave vertical dipole brings in a great many signals that cannot be heard on the big horizontal dipole, and is considered a complete success. Like L.B. says in his article, if you can buy a better antenna, by all means do so, but if you need an inexpensive, unobtrusive vertical, this one will do fine.

--KV5R

