The Super Sloper

Dramatically improve the front-to-back of a sloper.

By Roger Sparks, W7WKB
4311 Hanson Rd
Ellensburg, WA 98926
e-mail: rsparks@adsnet.net

You can imagine my surprise when *ELNEC*[1] revealed that a parasitic element can be combined with a long wire to form a whole family of directional antennas. There on my screen, I was looking at useful combinations not found in that bible of antennas, *The ARRL Antenna Book*. I had been exploring combinations of full-wave parasitic elements with wire arrays. How far off center can I slide a parasitic element, I wondered? "A lot" was the answer coming from *ELNEC* [and confirmed by *EZNEC—Ed.*]. As I offset a closely spaced (0.015 to 0.046 λ) parasitic element by 1/8 to 5/8 λ, a whole family of antennas appeared (see Figure 1).

I call the configuration a Super Sloper because the pattern resembles that of the well-known sloper, but it is greatly enhanced (see Figure 2). Super Slopers provide gain in the direction from the tall to the short pole. The amount of gain depends on antenna length, or more exactly, on the number of half wavelengths in each element.

Like slopers, Super Slopers require two supports, one tall and another shorter. At my station, and in this article, I considered only nonconductive supports. Other builders can explore the possibilities of Super Slopers suspended from metal towers. Super Slopers are very inexpensive to build (if you already have suitable supports). They require only wire and a few feet of PVC pipe.

Unlike slopers, Super Slopers have high feedpoint impedances. A matching network is required when feeding a Super Sloper with a 50-Ω line. The result is a broadband, low-Q antenna (Figure 3). Don't think of this as just one antenna, but rather a whole family of antennas, one for each half wavelength of added length.

Technical Concepts

If you just want to build an antenna, skip ahead to the Practical Antennas discussion. Those with a technical inclination can continue here, and they may even want to take a look at the discussion of long-wire antennas in *The ARRL Antenna Book*.

An antenna is called a *long wire* if it is one wavelength or longer. The radiation pattern can be described as the surfaces of two opposed cones that are coaxial with the wire and have their apexes meeting at the feed-point. The apex angle becomes smaller and the lobes grow stronger as antenna length increases. An azimuth plot of radiation pattern for single long-wire antennas over ground shows four principal lobes at low radiation angles. There are two principal lobes, *in one direction*, when the antenna is terminated in a matched, resistive load.

ELNEC shows that a parasitic element added to a single long-wire antenna creates a *unidirectional* radiation pattern similar to that created by a resistive termination. Energy eliminated from the back goes into useful forward gain. The parasitic element can be tuned as either a director or a reflector.[2]

Table 1
Spacing and Phase Angle for Various Antenna Lengths

At the spacings listed, the current in the resonant parasitic element is equal to driven-element current ±10%. (Derived from *ELNEC*, under free-space conditions, 0.25-λ offset, at 7.1 MHz.)

Antenna Length (λ)	*Spacing (λ)*	*Phase Angle (degrees)*
0.5	0.046	−156
1.0	0.030	−147
1.5	0.023	−144
2.0	0.018	−142
2.5	0.015	−142
3.0	0.015	−144

Table 2
Impedance and SWR versus Frequency (Figure 5)

Frequency (MHz)	*SWR (200 Ω)*	*Impedance*
14.0	1.54	293 + *j*48
14.1	1.25	248 + *j*13
14.2	1.16	172 + *j*0
14.3	1.75	127 + *j*54
14.4	2.61	107 + *j*113

Experience with Yagis (and many other applications of parasitic elements) led me to believe that all parasitic elements must be nearly a half wavelength long and located within the span of the driven element. That concept is completely *incorrect*. Parasitic elements can be *any* resonant length and offset from the driven element, as long as there is adequate coupling between the elements.

Here's how Super Slopers produce front-to-back ratio (F/B) and gain. The best F/B results from a 180° phase shift between the currents in the driven and parasitic wires, as seen from a distant location where a pattern null is desired. A phase difference of 180° means that the signals completely cancel each other, if each element delivers equal signal strength. A phase shift of 90° is possible with a 1/4-λ offset, and the remaining 90° phase shift can come from the tuning (length) of the parasitic element. If the fields cancel in one direction, they will reinforce in some other direction, to produce gain.

By increasing the phase angle of the current in the parasitic element, the angle of maximum cancellation can be moved. This is particularly useful in Super Slopers because the principal lobes of long wires lay at some small angle to the direction of the wire. From Table 1, notice that the current in a resonant parasitic element has about −144° to −156° phasing, which is about right for correct reverse-lobe canceling.

If we want each element to deliver equal signal strengths to a distant location, nearly equal currents must flow in both the driven

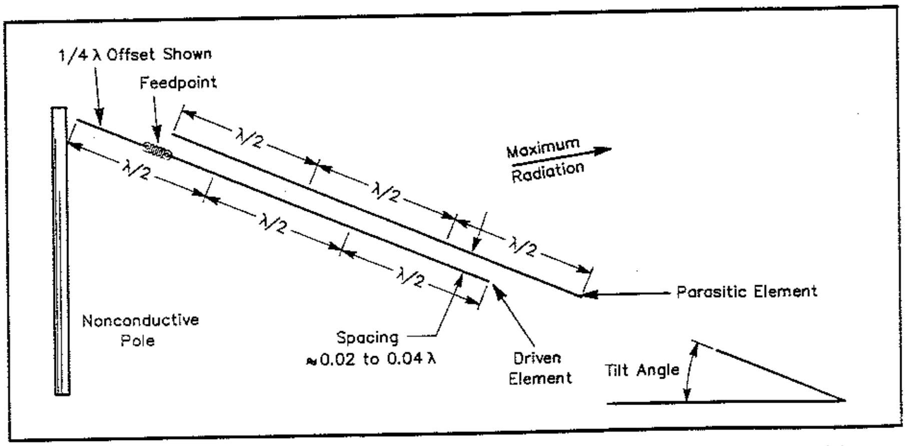

Figure 1—Drawing of a Super-Sloper antenna showing nomenclature. This is a 3-λ/2 model. See Figure 7 for construction details.

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[1] Notes appear on page 35.

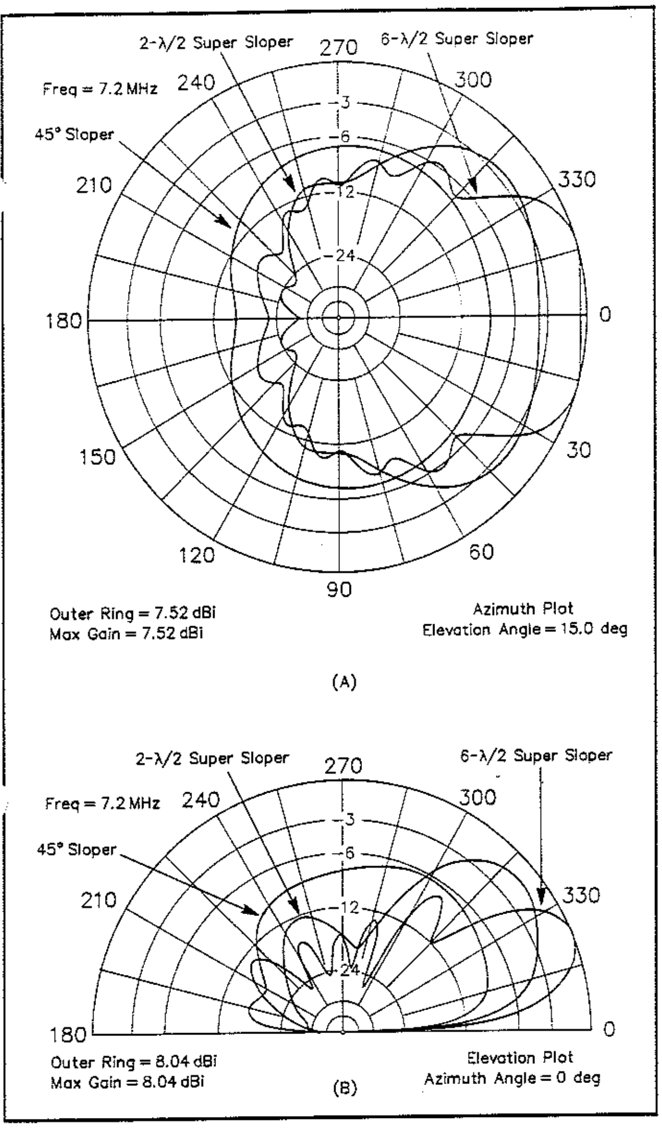


Figure 2—Azimuth (A) and elevation (B) plots for a 45° sloper, 2-λ/2 (0.25-λ offset, spaced 0.04 λ, low end 0.119 λ above ground) and 6λ/2 (0.25-λ offset, spaced 0.015 λ, low end at 0.066 λ above ground) Super Slopers. The high end of each is λ/2 high.

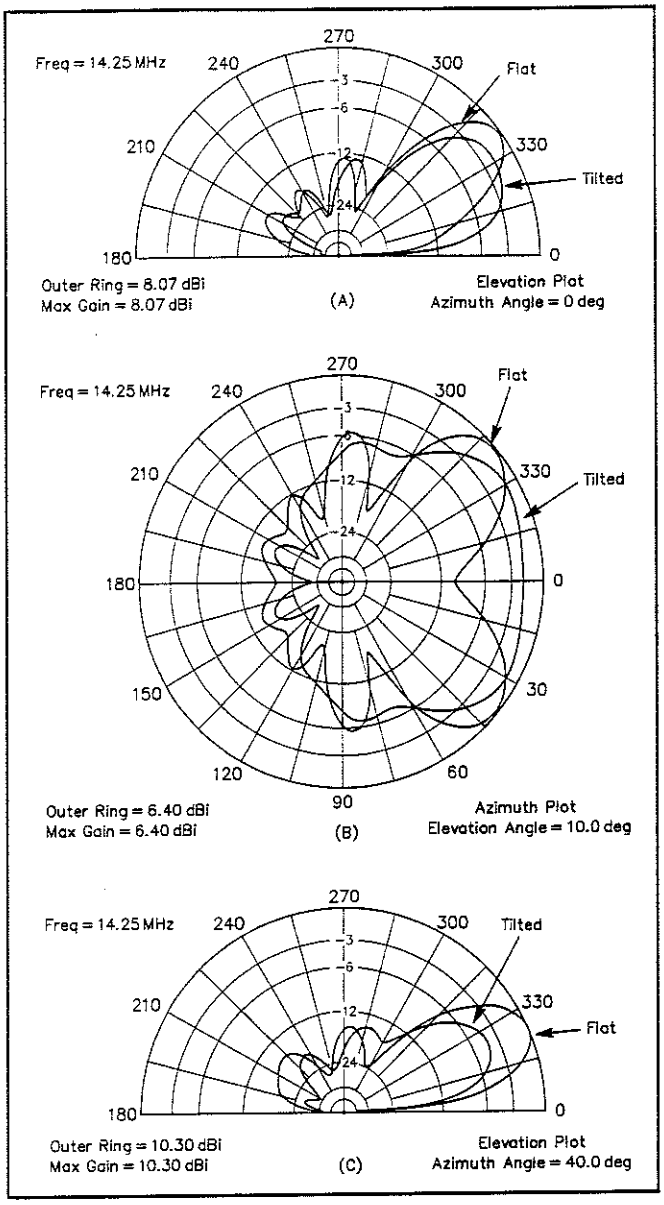


Figure 4—Patterns of a 3-λ/2 antenna with 0.36-λ offset and spaced 0.04-λ oriented flat at 1/2 λ vs sloping from 1/2 λ to 0.045 λ. A shows the elevation patterns at 0°; B shows the azimuth patterns; C shows elevation plots at azimuth = 40°.

and parasitic elements: The coupling between elements must be very close. Table 1 suggests the approximate spacings for currents to be equal within ±10%. (The antenna also has gain at closer spacings because gain is affected less by unequal currents than is F/B.)

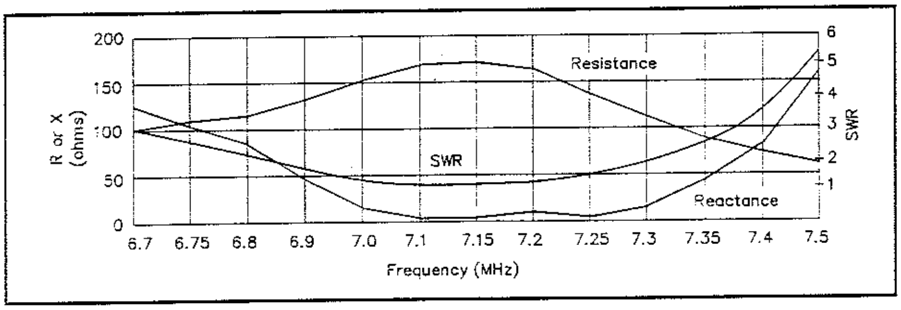


Figure 3—A plot of impedance and SWR versus frequency for the 2-λ/2 antenna described in Table 6, placed as described in Figure 6. The data source is *NEC/WIRES 1.5* (see Note 3).

Designing a Super Sloper

When placed near (and parallel to) the ground, Super Slopers show twin-lobed azimuth patterns with a null, often 10 dB or greater, on the axis of the wire. This center null can be filled by tilting the wire, with the low end in the direction of the null. Figure 4 shows the effects of tilting.

When the antenna is tilted, the end of the parasitic element can become closer to the ground than that of the driven element. When considered as two separate antennas at different heights, the driven and parasitic elements will not have the same patterns. This reduces performance, but locating the parasitic element so that its end height equals that of the driven element can solve the problem. That is, increase the spacing to place the parasitic element end above that of the driven element. Models give this design 1 to 2-dB gain advantage over more closely spaced antennas, but construction is a greater mechanical challenge.

The driven element is fed at a current antinode, 1/4 λ from an end. The antennas can be made to exhibit a wide range of feed resistances: 20 to 300 Ω, or more (see Tables 2, 3 and 4). High resistances and wide offsets combine to produce low SWR and useful gain over an unusually great bandwidth (Table 2). I've used ¼-λ matching lines (using RG-62, a 93-Ω line), 4:1 baluns and ladder lines to successfully match the antenna at high impedances.

You can vary the antenna length (gain increases with length), height, offset, phasing and spacing as needed. These many variables would be difficult to work with if each were a critical adjustment, but fortunately, they are not critical. Tables 1, 3, 4 and 5 show the tolerant design features of these antennas. From these tables, we can observe several trends:

- Current balance greatly affects F/B, with less effect on gain.
- Phase angles change very slowly with antenna length.
- Gain changes very little with changes of current and phasing.
- Gain varies by a little over 1 dB with a spacing increase from 0.01 to 0.04 λ.
- Gain is nearly constant with offsets moving from 0.1 to 0.4 λ.

Good F/B is easy to achieve, even though the antenna is designed for best gain or easy construction. Improved F/B ratios and reverse-oriented patterns are possible from designs optimized at specific frequencies. Computer modeling is the best way to optimize reverse patterns. Figures 5 and 6 show some possible patterns and how the patterns vary with frequency. Table 2 and Figure 3 show predicted SWR.

Table 3
Element Spacing versus Phase Angle, Relative Current, Impedance, Gain and Lobe Angle

Derived from *ELNEC* free-space model, 14.2 MHz, 2-λ/2 elements, offset 0.25 λ

Spacing (l)	*Phase Angle (degrees)*	*Relative Current*	*Impedance of Driven Element*	*Gain (dBi)*	*Lobe Angle (degrees)*
0.01	–136	1.62	205 – *j*230	4.98	48
0.02	–141	1.29	128 – *j*138	5.54	48
0.03	–144	1.11	103 – *j*94	5.78	48
0.04	–149	0.97	80 – *j*59	6.1	48

Table 4
Offset versus Phase Angle, Relative Current, Impedance, Gain and Lobe Angle

Derived from *ELNEC*, free-space model, 14.2 MHz, 2-λ/2 elements, spaced 0.02 λ. Notice how little gain changes with different offsets.

Offset (λ)	*Phase Angle (degrees)*	*Relative Current*	*Impedance of Driven Element*	*Gain (dBi)*	*Lobe Angle (degrees)*
0.1	–167	1.08	19 – *j*54	5.7	48
0.15	–157	1.18	48 – *j*101	5.67	48
0.2	–148	1.26	89 – *j*135	5.6	48
0.25	–141	1.29	128 – *j*138	5.57	48
0.3	–139	1.16	134 – *j*111	5.6	48
0.35	–138	0.963	123 – *j*70	5.58	48
0.4	–134	0.71	108 – *j*14	5.4	48
Pattern Reversal Begins					
0.5	–26	0.25	83 + *j*46	3.0	54
0.6	39	1.31	126 – *j*57	5.2	61
0.7	43	1.71	192 – *j*180	4.0	64

Practical Antennas

Table 6 describes Super Slopers constructed at my station (refer to Figure 1 for nomenclature). The principal difference between the two 3-λ/2, 20-meter antennas in Table 6 is the increased offset from 17½ feet to 22 feet. This changes the phasing, resulting in a slightly improved F/B ratio and slightly improved gain. The tradeoff is a narrower pattern and a longer antenna.

A 60-foot mast supported the 3-λ/2 and 2-λ/2 20-meter versions. They were mounted back-to-back and tilted to fill the center null. Another 3-λ/2, 20-meter unit was mounted from a 38-foot mast. The

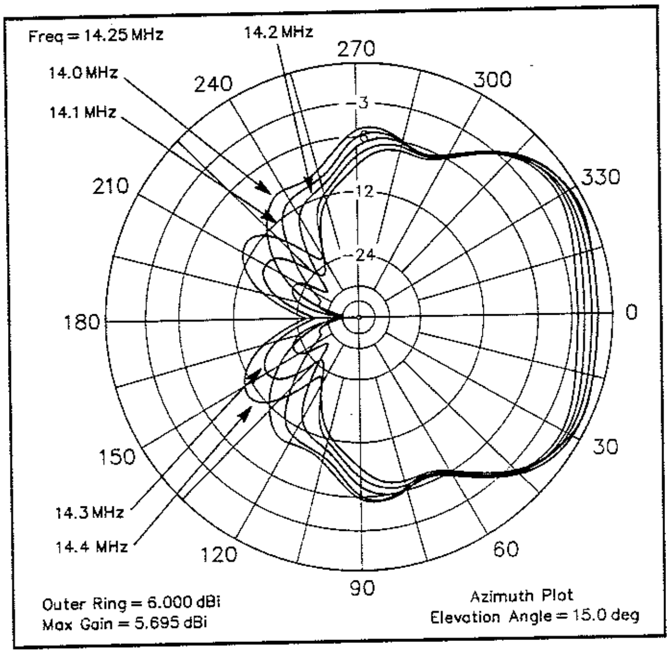


Figure 5—A radiation pattern over a range from 14.0 to 14.4 MHz. The pattern is that of a 3-λ/2 antenna with 0.36 λ offset, with the ends at ½ λ and 0.045 λ. See Table 2 for the SWR tabulation.

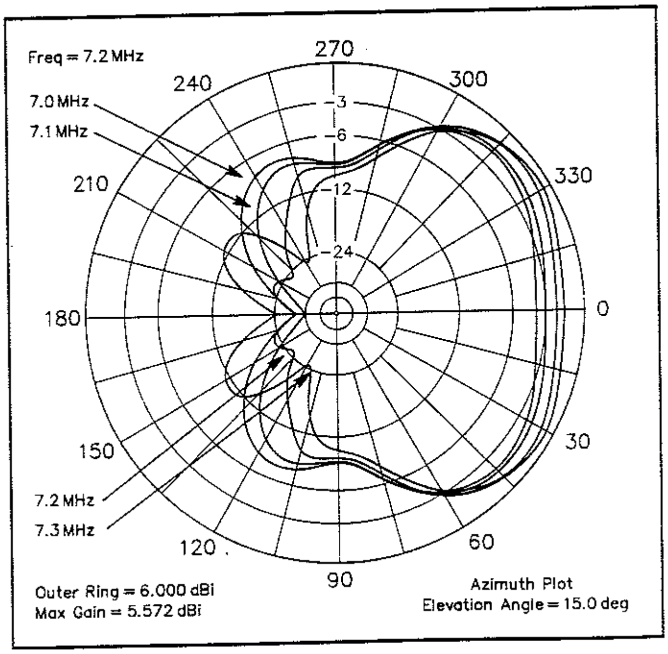


Figure 6—Pattern plots over a frequency range from 7.0 to 7.3 MHz. The antenna is 2-λ/2, with 0.25-λ offset and 0.04-λ spacing. The driven element is 1.02-λ long; the director is 0.98-λ long. See Figure 3 for an SWR curve.

40-meter version sloped from 60 feet down to 6 feet. All antennas performed as predicted. Additional height at either end definitely increases low-angle radiation, but it reduces high-angle radiation.

Figure 7 shows how I assembled and spread the wires. The departure from straight lines (as depicted in Figure 1) has no practical affect on the antenna. Be sure to place the director over the driven element when erecting the antenna. A director placed at the side will skew the pattern, favoring the side of the director. Keep the Super-Sloper support lines tight to minimize sagging. Severe sagging leads to improper phasing and degraded results. I put a support under my 40-meter Super Sloper at midspan, but I just pull the 20-meter antenna support lines tight. The two elements have a tendency to twist and wrap together in the wind. You can prevent this by using two support ropes at the low end or by using spacers as on transmission lines. Both methods work well. Super Sloper performance suffers from excessive ground losses when the low end is at ground level. I strive for an antenna slope (tilt angle) of 10° to 20° and a minimum height of 6 feet. Higher is better.

Table 5
Parasitic Element Length versus Phase Angle, Relative Current, Gain and Lobe Angle

Derived from *ELNEC*, under free-space conditions with 14.2 MHz, 2-λ/2 elements, spaced 0.02 λ apart.

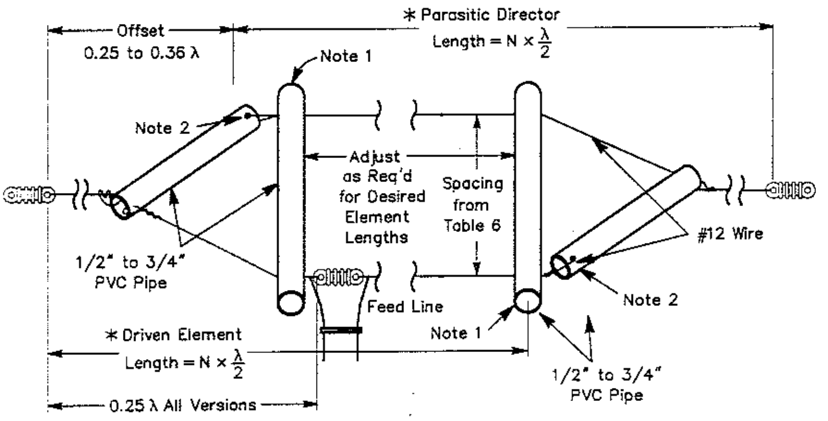
Percent Short (λ)	*Phase Angle (degrees)*	*Relative Current*	*Gain (dBi)*	*Lobe Angle (degrees)*
0	−140	1.30	5.54	48
1	−125	1.47	5.33	49
2	−107	1.53	5.02	51
3	−89	1.43	4.70	52
4	−75	1.23	4.44	53
5	−65	1.05	4.19	53

Table 6
Working Antenna Dimensions

Use a 4:1 step-down transformation to match 50-Ω line.

Antenna Number	*1*	*2*	*3*	*4*	*5*	*6*
Band	40 m	20 m	20 m	20 m	15 m	10 m
Length*	2	3	3	2	2	2
Driven (ft)	139.3	106.5	105.6	70	46	34.5
Director (ft)	134.3	104.0	102.2	68	45	32.8
Offset (ft)†‡	34.3	17.5	22	17.5	11.5	8.6
Spacing (ft)	6	1.5	1.5	1.5	1.0	1.0
Feedpoint (ft)‡	34.3	17.5	17.25	17.5	11.5	8.6

*Length expressed as a multiple of λ/2.
†Offset is λ/4, except for antenna 3, where the offset is 0.31 λ.
‡Feedpoint and offset are both measured from the high end of the driven element.



Note 1. Spreader length is 2" longer than spacing. Wires are threaded through holes drilled in spreaders.

Note 2. Tension member is 2" longer than 0.60 × spacing. Wires are threaded through holes drilled 1" from each end.

* Length must be adjusted for optimum gain or F/B ratio. Begin with lengths given in Table 6.

λ = Wavelength

Figure 7—A method of constructing the long-wire parasitic antenna. Additional center spacers reduce the tendency of the wires to twist in the wind.

A 200-Ω feedpoint impedance is easily transformed to 50 Ω with a 4:1 balun. Ladder line and a tuner are another option. Refer to *The ARRL Antenna Book* for other methods of transforming high feed impedances to values acceptable for modern transceivers. Do not feed the Super Sloper directly with coax unless the coax is part of an impedance-matching section.

Results and Conclusions

I've built and used six Super Slopers very successfully. The F/B is often dramatic. A difference of six S units is not uncommon when switching between two antennas built to favor opposite directions.

This family of antennas has not yet been well researched and studied. Use an antenna modeling program before building designs that are substantially different (eg, longer or made from tubing) from those described in Table 6.

Notes

[1] *ELNEC*, and its successor *EZNEC*, are computer antenna modeling programs available from Roy Lewallen, W7EL, PO Box 6658, Beaverton, OR 97007. The description files for the antenna plots shown in this article are available as a self-extracting archive file named SUPSLOPE.EXE. This file can be found on the Internet (FTP to OAK.OAKLAND.EDU, directory pub/hamradio/arrl/qst-binaries) and on the ARRL BBS (860-594-0306).

[2] Parasitic elements offset more than ½ λ from the driven element, become reflectors.

[3] *NEC/WIRES 1.5* is a computer antenna modeling program available from Brian Beezley, K6STI, 3532 Linda Vista, San Marcos, CA 92069.

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