The 64 - (Euro) Dollar Question

L. B. Cebik, W4RNL (SK)

U.S. amateur operators have access to the 6-meter (50-54-MHz) band. However, they do not have access to a small band open to UK hams: the 4-meter (70-70.5-MHz) band. Only some Region 1 countries share that middle ground between 6 and 2 meters. UK amateur also generally have smaller plots on which to erect antenna farms. Very often, a chimney-supported mast is the only available antenna support. Hence, multi-band antennas for small spaces are always popular reading (and building) projects.

A reasonable combination of bands for the chimney top is 6 and 4 meters. The relationship between bands is roughly equivalent to the relationship between 20 and 15 meters: about a 0.75:1 frequency ratio. Hence, there are numerous options open to UK ham in need of a combined 6/4-meter antenna. As a bonus, I shall throw a single feedline into the mix.

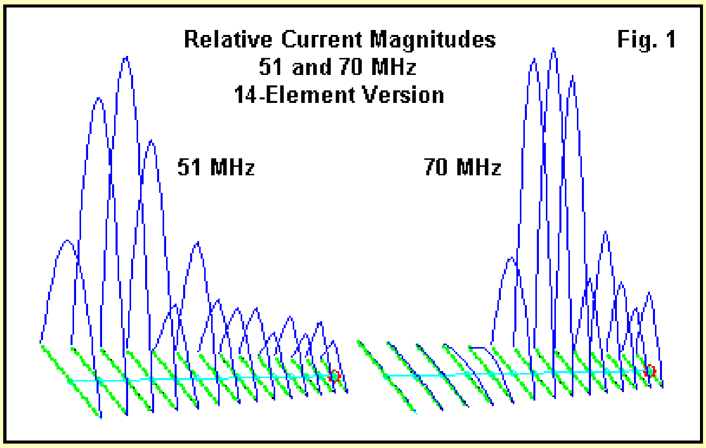
Most roof-top antenna mounters also add a special caveat into the mix: keep the boom length to about 6'. This desire opens a different door on the problem of multi-band antennas: the antenna mythology arising out of the 1960s through the 1980s. If my reading has been representative, it is fraught with misdirection. So, although we shall try to stick to the 6' boom limit, we shall not always succeed.

In fact, we shall look at two directions of design for 6/4-meter antennas. One path will lead us into LPDA and related designs. The other road will have a "Yagi" label. Neither direction will give us a perfect antenna--where perfect also means easy to build--but both will lead to usable solutions for the careful antenna builder.

The Path to LPDAs

Much of the foundation for LPDAs, log-cell-Yagis (also called LPYs or log-Yagis), and similar structures comes from the era just before the advent of very good antenna modeling software. As a result, the material found in many amateur journals and books is filled with misconceptions arising from one-of-a-kind successes generalized well beyond the limits of what analysis will bear.

For example, in LPDA design (whether for an entire array or for the driven cell in an array with reflectors and/or directors), we encounter the idea that if we make an element resonant for each desired band within the array, we shall improve performance in some way. Unfortunately, that idea stems from the old and erroneous assumption that an LPDA operates like a selective 3-element Yagi. The element just longer than the resonant one is a reflector and the element just shorter than the resonant one is a director. This idea is faulty on at least two counts, as illustrated in **Fig. 1**.



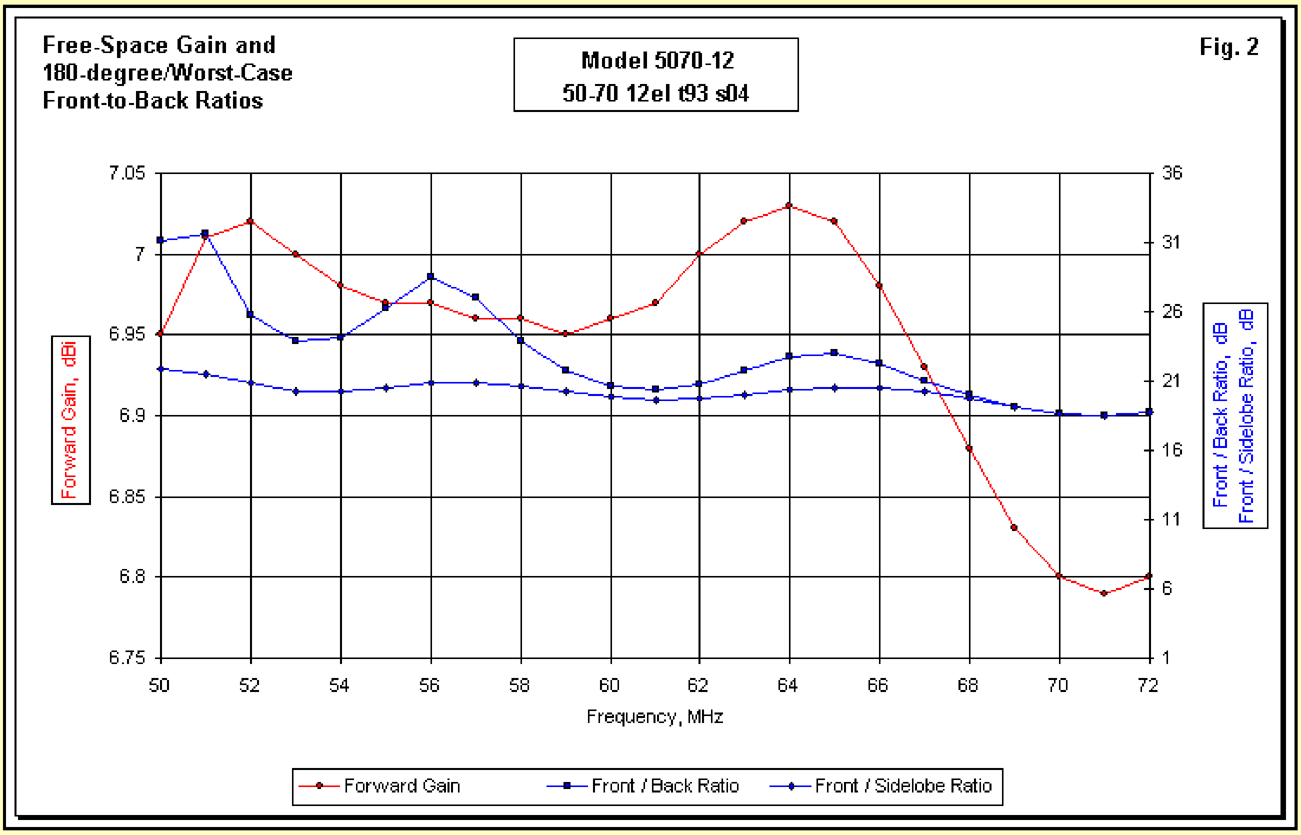
1. Although an individual element may be somewhat more active--as determined by the peak current magnitude on it--multiple elements show high current levels in a well populated LPDA. The 70-MHz portion of **Fig. 1** is especially graphic on this point, where 3 elements have very nearly equal current magnitudes.

2. Virtually all of the elements forward of the most active element on any frequency are significantly active in terms of showing high current magnitudes (in contrast to the relatively inert elements well behind the most active one). The 3-element Yagi analogy simply does not apply to an LPDA.

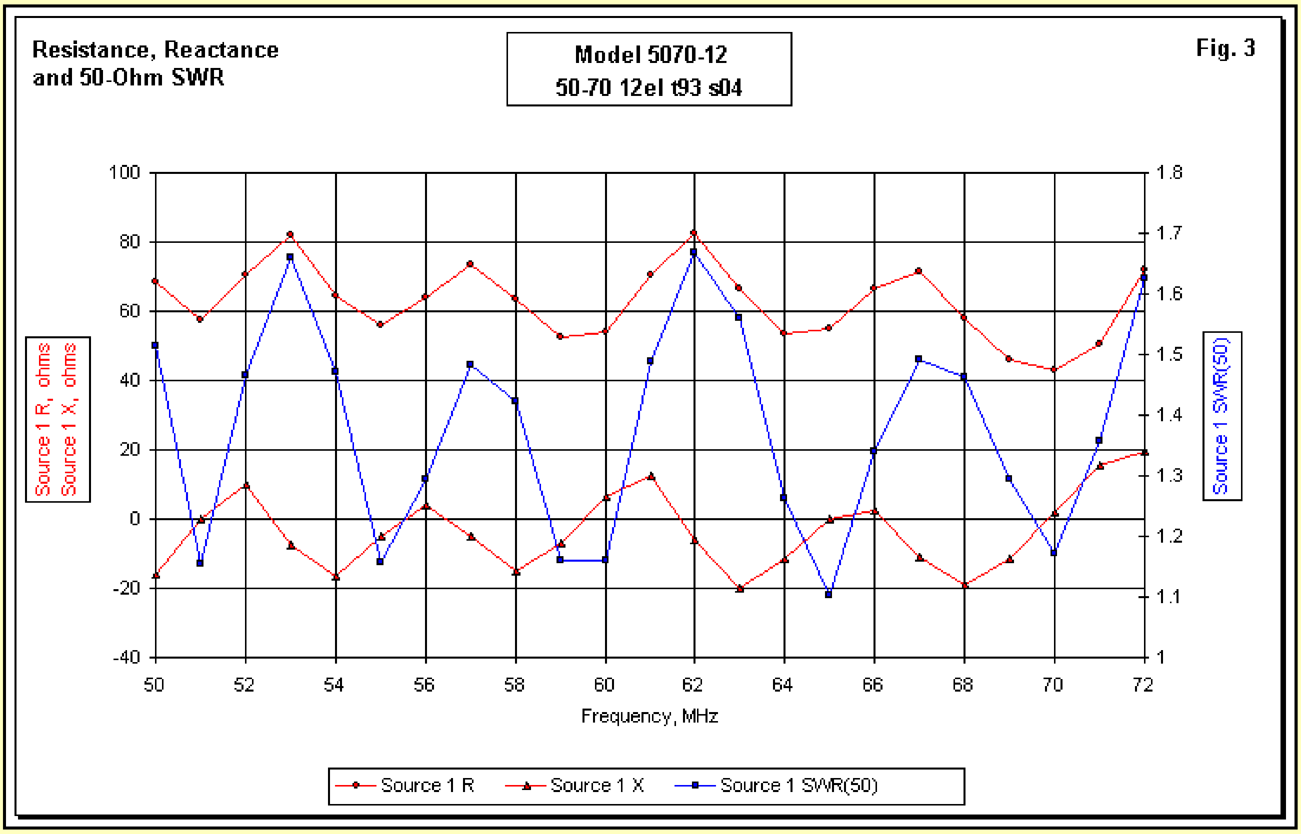
Another misconception follows on this first one. Most calculating programs for LPDA designs set the resonant frequency of the shortest element about 1.3 times the highest frequency in the operating pass band. Although this formula might work with LPDAs using very long booms, very many elements, a very high value of Tau, and an ideal value of Sigma, the multiplier is too small for the smaller, less populated LPDAs designed by amateurs. As a result, the smaller LPDAs experience considerable high-end performance degradation relative to performance in the middle of the passband. A value closer to 1.6 times the highest frequency used is closer to reality for a design with comparable performance throughout the passband.

As a result of these and other misconceptions about LPDAs, most LPDAs and log cells designed by amateurs tend to have too few elements and unsatisfactory performance at the high end of the scale. But before we enter the actual task of redesigning the LPDA for 6 and 4 meters, lets examine another problem: misguided expectations. Many amateurs expect LPDAs to provide smooth performance across their entire passbands. Hence, if a performance number is out of line with the expected single value set, something must be wrong.

What is wrong is the idea of expecting smooth LPDA performance with the types of values of Tau, Sigma, and element count typical of amateur LPDAs. LPDAs show cyclical performance, with peaks and valleys of gain and front-to-back ratio, as illustrated in **Fig. 2**.



The particular LPDA only has a 1.5:1 frequency range and therefore shows only two gain cycle. Do not make too much of the depth of the visual curve, since it only represents a change of 0.24 dB. The 180-degree front-to-back line shows more numerous peaks and valleys--and they do not necessarily coincide with the peaks and valleys in the gain curve. (The front-to-side line in the graph actually represents the worst-case front-to-back ratio and is much more constant than the 180-degree curve.) The exact performance of an LPDA depends on both the directly fed power to the elements and the mutual coupling among the elements. Hence, it is natural that, in this environment where the ratio of the two changes with every small change in operating frequency, the gain and front-to-back curves do not coincide.



The resistance, reactance, and SWR curves also reflect these conditions, as shown in **Fig. 3**. Resistance and reactance do not show resistive peaks and inductively reactive peaks at the same frequencies. A well design LPDA tends to show its highest values of reactance (either inductive or capacitive) when the resistance is closest to the median value for the array. Equally, the lowest reactance values tend to occur when the resistance is furthest from its median value. Hence, although subject to ups and downs of its own, the LPDA's SWR value--in a well-designed array--tends to be acceptable (relative to some design standard) across a very wide passband.

So what can we do for the 50-70 MHz span? The answer is that we can design a fair number of different LPDAs to cover this spread. Each version uses a design frequency range of 50 to 87 MHz. The calculations give us a lower frequency longest element and a higher frequency shortest element.

The end result is a series of LPDAs each of which has the following physical properties:

1. A longest element that is 120.4" from tip to tip.

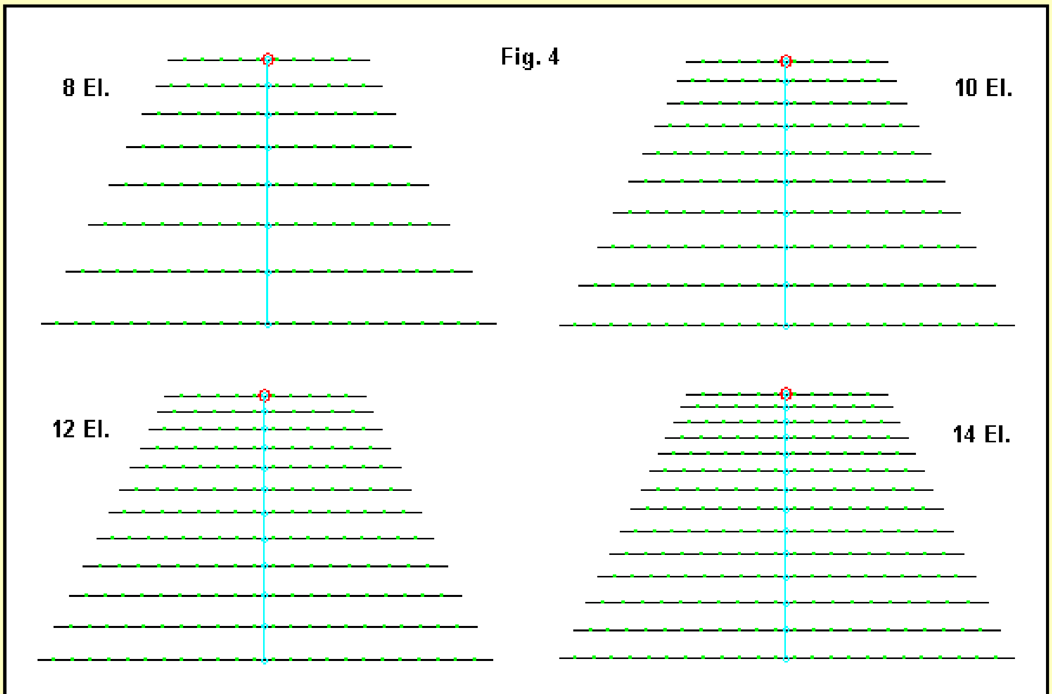
2. A shortest element that is 53.25" from tip to tip.

3. A total element length of 70", which allows a bit of space on a 72" boom for mounting hardware.

4. A variable number of elements, from 8 through 12, with consequential variations in overall performance, performance curve shapes, and values of Tau and Sigma.

In all cases, the performance at 6 meters is very comparable to the performance at 4 meters. The frequencies in between are largely allocated to television, so the antenna will handle to channels below about 75 MHz.

Full dimensions--as presented in model description format--appear at the end of the article. However, **Fig. 4** provides the outlines for the 4 sample LPDAs.



Comparative Sizes of the 50-70-MHz LPDA Series: All Booms: 70"
Longest and Shortest Elements Identical in All Versions

As the outline sketch makes apparent, the only difference in appearance among the 4 LPDA designs is the element population. The following table provides of the basic design and performance information about the arrays.

. . . .

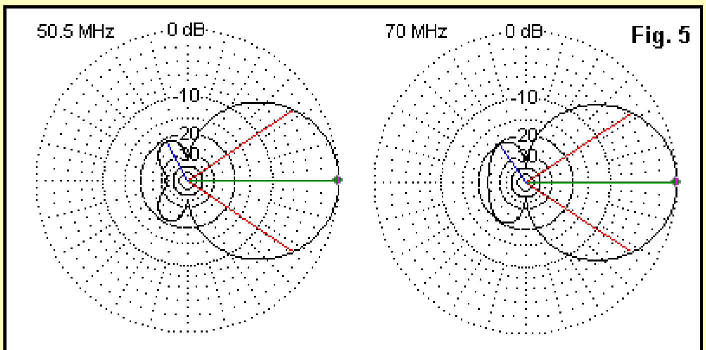
Design and Performance Data for the 6/4-Meter LPDAs

No. El.	Tau	Sigma	51-MHz Gain	51-MHz 180-F-B	70-MHz Gain	70-MHz 180-F-B
8	0.89	0.06	6.58	20.25	6.69	18.41
10	0.91	0.05	6.85	35.42	6.94	22.06
12	0.93	0.04	7.01	31.64	6.80	18.68
14	0.94	0.03	7.13	27.02	6.94	21.04

All gain values are for free-space. All data from NEC-4 models.

. . . .

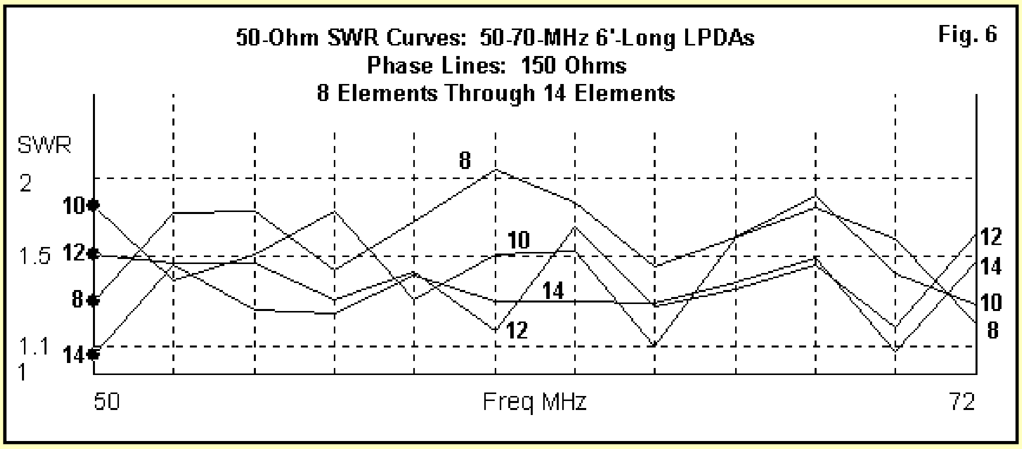
Do not cheer too loudly at some of the very high 180-degree front-to-back ratios, since they are subject to spikes. Indeed, construction variations can easily move the high peak away from the listed frequency and present only a more modest value. However, in general, the arrays show--across their entire passbands--an increasing level of performance as we increase the element count. However, we cannot proceed indefinitely, because the value of Sigma is decreasing. With that decrease comes a need for employing other optimizing techniques to sustain performance at 70 MHz.



General Azimuth Pattern Shape at 50.5 and 70 MHz
(10-Element Model Used for Demonstration)

Fig. 5 shows azimuth patterns at 50.5 and 70 MHz for the 10-element array. The patterns are typical and completely well behaved, since the small operating frequency span does not stress the design in any way. Note in the lower-frequency pattern that the 180-degree front-to-back value does not show the true rearward performance as well as would a worst-case value using the strongest rearward lobe gain. With that figure, there is little difference between the 50- and the 70-MHz patterns.

All of the arrays use a 150-Ohm phase line so that the target feedpoint impedance is 50 Ohms without need for any conversion. A few ferrite beads on the coax at the feedpoint will suppress any tendencies toward common-mode currents on the feedline to the array. However, using the same characteristic impedance for the phase line between elements does not guarantee that all of the versions of the LPDA will yield the same SWR curves. See **Fig. 6**.



If you carefully track the lines for each array, you will discover that the 14-element array has the smoothest performance and the lowest average value of 50-Ohm SWR. The 8-element version shows one peak (outside any ham band) above 2:1 and also reveals the most erratic progression. The conclusion that higher values of Tau tend to smooth the impedance curves is a correct one on which to generalize--within overall design limits.

The following table provides modeled performance for the 10-element version at heights of 20' and 35' above average ground. you can extrapolate both for the other models and for other heights.

. . . .

10-Element LPDA Performance

	50.5 MHz			**70 MHz**		
Height	**Gain dBi**	**F-B dB**	**Feed Z**	**Gain dBi**	**F-B db**	**Feed Z**
F.S.	**6.8**	**28.2**	**88 - j 4**	**6.9**	**22.1**	**60 - j17**
20'	**12.1**	**22.1**	**84 - j 2**	**12.5**	**23.8**	**58 - j15**
35'	**12.4**	**33.2**	**89 - j 6**	**12.7**	**23.9**	**59 - j16**

. . . .

The values are better directional performance figures than they are raw gain figures. Since they are far field figures at the elevation angle of maximum radiation (TO angle), the performance in point-to-point use may differ somewhat.

A final misconception attaching to many types of arrays is the gain potential. Gain potential is largely a matter of boom length and not the number of elements. As the range of LPDA populations shows, adding elements may show a slight increase in forward gain, but the true merit of using more elements within a given boom-length lies elsewhere. Whether an LPDA or a Yagi, further elements on the same boom gives the designer more flexibility in setting the feedpoint impedance level at maximum gain and also permits a wider operating bandwidth within the pre-set SWR limits. If you want more gain, you will have to use a longer boom. For Yagis, one can extend the boom length almost without limit. However, an LPDA will peak out at a gain of about 12 dBi (free space).

Can I build any of the LPDAs? There are at least two ways to build an LPDA for the VHF range and upward: using 1 boom and a separate phase line assembly and using 2 booms and letting them double as the phase line. In both cases, we must ensure that we have a phase reversal of the phase line with each element. That means give the line a half-twist between each pair of elements. Actually, there are better ways to perform the reversal technique while sustaining the line's integrity and characteristic impedance.

However, it is very important to use a phase line impedance of 150 Ohms or slightly less. A higher impedance will raise the average impedance at the feedpoint and may not yield a direct 50-Ohm feed for the array. In addition, increasing the phase-line characteristic impedance will also lower the array performance, with low figures for both gain and front-to- back ratio.

. . . .

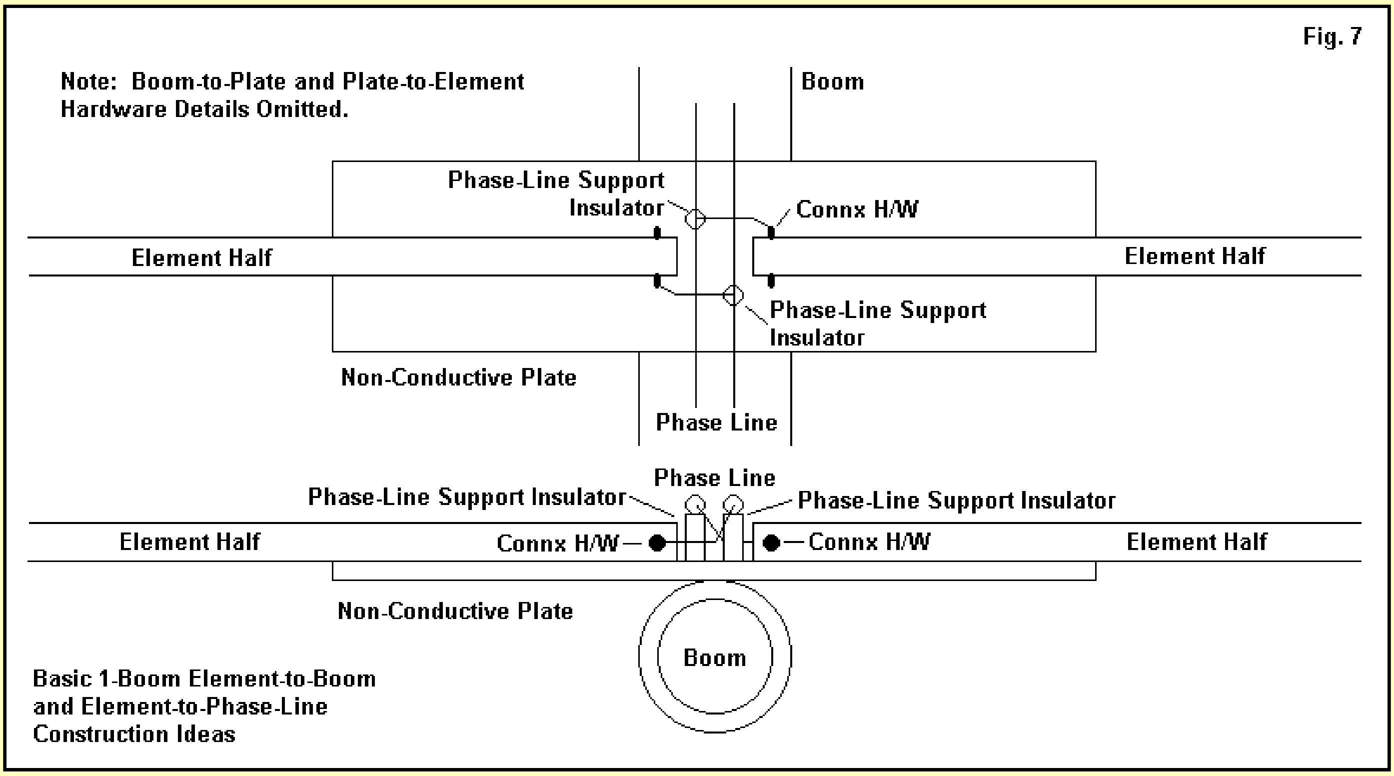
Phase Line Structures and Dimensions: 150 Ohms

Conductors	Center-to-Center Distance	Gap Distance
#12 copper	0.153"	0.072"
#14 copper	0.121"	0.057"
1" square tubes	2.222"	1.222"
3/4" square tubes	1.667"	0.917"

. . . .

The first two line types are for the 1-boom version of the array. The final two are for the twin-boom version.

The 1-boom LPDA: A 6' length of aluminum tubing or PVC forms a good boom for the 1-boom LPDA. The dimensions at the end of this article are for elements that are well insulated and isolated from any conductor, including a boom. Therefore, the use of non-conductive plates to support the elements is essential. **Fig. 7** shows the general layout.



The sketch omits the usual U-bolts that connect the plate to the boom and the nuts and bolts that connect the elements to the plates. Please use stainless steel hardware throughout the assembly to avoid bimetallic electrolysis and hardware rusting.

Every element in an LPDA is split, with a small gap at the center. As the sketch indicates, we can support the phase line on small pillars or blocks. At each element junction, we add very short jumpers to the element halves. On odd numbered elements, we use direct jumpers, while on even numbered elements, we use crossing jumpers. (Or vice versa.) This technique ensures that we reverse the phase line with each element while keeping the actual phase line straight and true. Since I am presuming the use of copper wire phase line materials, soldering the jumpers to the lines is wise, while screws or nut-and-bolt combinations attach the jumpers to the elements. Use stainless steel washers or a similar technique to prevent a copper-to-aluminum contact.

At the forward end of the array, where the element density is high, the mounting blocks may suffice to maintain the spacing between phase line wires. However, at the rear end of the array, you may need to use thin spacers and perhaps glass tape to keep the line exactly spaced and parallel. In all cases, you may wish to seal the spaces and the jumper junctions with Plasti-Dip^{TM} or a similar product. Plasti-Dip is also handy for sealing the end of a length of coax soldered to the froward-most terminals or to seal the rear side of a coax connector that you attach to the front end of the boom.

The original designs of the LPDA family used no rear shorting stub. However, you may attach one to the center of the longest element by extending the line and soldering its free ends together. The length of the line will vary from 1 to 6 inches in most cases. Construction variables will determine how long a stub to use. The stub will affect performance, including impedance, at the lowest frequencies of use, so select a line length that gives you the best operating and SWR performance. The stub is not necessary for operation of the array. However. it does place both sets of half-elements at the same potential, thereby reduce noise from static charge build-up on the elements.

The 2-boom array: A twin-boom version of the LPDA family is certainly possible using techniques that I used on a 2-meter LPDA that appeared in *QST* a couple of years ago. There, I used U-channel for 3/16" rod elements. In these arrays, all elements are 1/2" aluminum tubes, so we need a variation on that technique. Incidentally, for the longest elements, using inner sections of 5/8" aluminum tubing, with outer sections of 1/2" diameter material will not affect overall performance, but may move the peaks and valleys in the performance curves to slightly different frequencies.

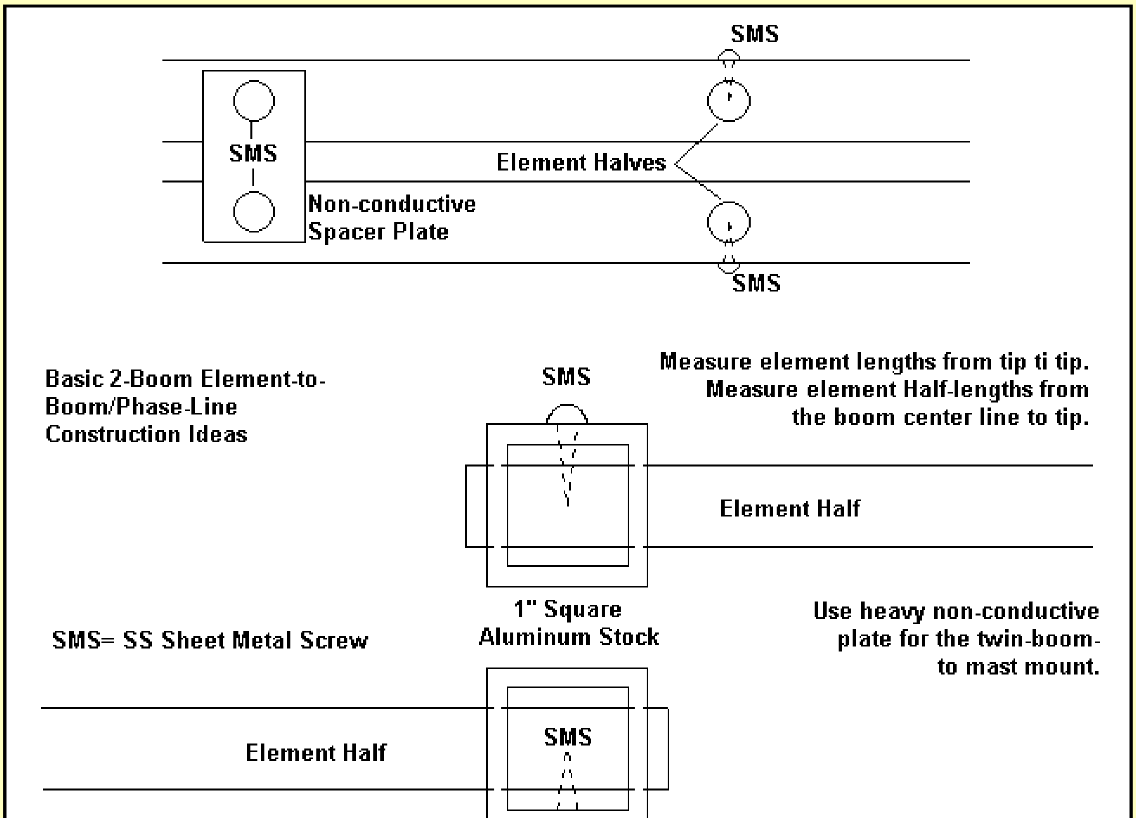


Fig. 8

Fig. 8 shows the basic ingredients of twin-boom construction using 1" square tubes. For each element, we drill through both sides of each tube with 1/2" holes. We mount each half element in a hole, alternating which half goes on top and which on the bottom. This mounting method ensures a phase reversal with each new element in the set. We can secure each tube in place with a sheet metal screw that penetrates the element. The screw heads go on the outside of the tubes, not on the sides facing each other. The heads would disturb the impedance of the phase line formed by the precisely spaced tubes.

To space the tubes, we place periodic non-conductive plates along the twin-tube assembly, using either sheet metal screws or through hardware at each point. Use a plate on each side of the tubes to reduce stress on the plates. As well, use a stiff non-conductive plate to connect the booms to the mast. My personal preferences for all such plates is polycarbonate (also called Lexan^{TM}). However, other materials will also do the job if they are UV protected.

At the front end of the array, at the forward-most elements, you will need to attach a length of coax (with common-mode current attenuating beads) or a coax connector for the main feedline. As with the 1-boom mode, Plasti-Dip or similar materials seal the connections.

The 2-boom version eases the problem of making a reliable phase line, but involves more metal work and results in a heavier antenna. Which method you choose depends on available materials and your own skills. However, let's not make a choice until we see what a Yagi may have to offer to dual-band operation.

The Road to a Yagi

Because the Yagi array is by nature narrow band, with rarely more than about a 10% operating bandwidth, it tends to yield more gain per unit of boom length. However, we shall not quite make our 6' limit with the design that will follow. Essentially, the 6-meter portion of the array requires about 73.5" between the rear and forward elements for its performance. The upper-band forward-most director is at 79" from the 6-meter reflector. If we add a bit more for the boom-to-element assemblies, the length may end up about 82-84 inches long.

The real challenge in creating a 2-band array is placing the elements so that the array performs well on both bands. As well, we need a technique to allow us to use a single feedline. The feed technique is some-times called direct feed, but I prefer the term "closed-sleeve coupling." Like open-sleeve coupling, used on many Force 12 HF beams, the two drivers are close enough together so the mutual coupling determines a good part of the effectiveness and impedance at the feedpoint on the upper band. However, rather than just using mutual coupling, we also use a short length of transmission line between the actual feedpoint on the longer driver and the shorter driver. Hence, we have a dual driver system, similar to that used on current production models of the Bencher Skyhawk and the HF series of arrays by Optibeam.

The line that I specify in the model is 100-Ohms at a velocity factor of 1.0. To form this line, you can use short, thin, square bars of brass or copper. However, you can also press into service RG-62 coax at 93 Ohms. The line is so short that the performance of the array will not change significantly. Even 75-Ohm twin lead will work.

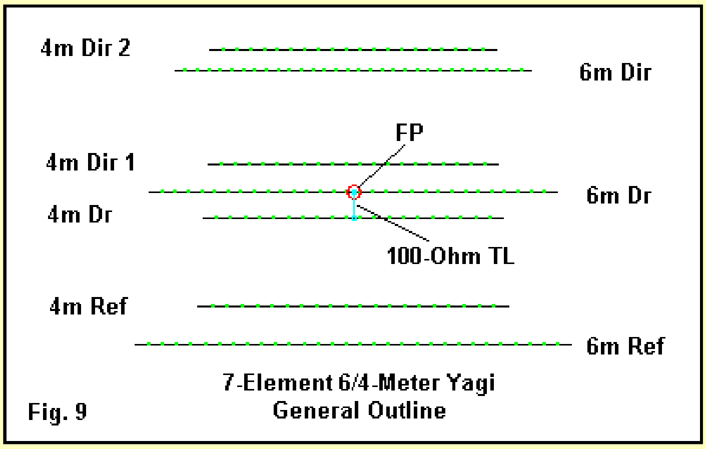


Fig. 9 7-Element 6/4-Meter Yagi General Outline

In **Fig. 9**, we can see the general layout of the array. It uses 3 elements on 6 meters. The elements are set for very wide-band operation that covers all of the 6-meter band with about 7 dBi of free-space gain and an average front-to-back ratio of nearly 20 dB. We can get more gain from three elements on the boom size we are using, but I opted for a bit less gain and more operating bandwidth. The full beam dimensions--in model format--appear at the end of these notes. Once more, all elements are specified as 1/2" diameter. However, on the 6-meter elements, you can use inner sections of 5/8" diameter tubes. Likely the only needed change will be a slight readjustment of the 6-meter driver to obtain under 2:1 50-Ohm SWR at both ends of 6 meters.

On 4 meters, we need more elements to make the beam work. I chose 4, although one might even make a case for 5. **Fig. 10** shows why.

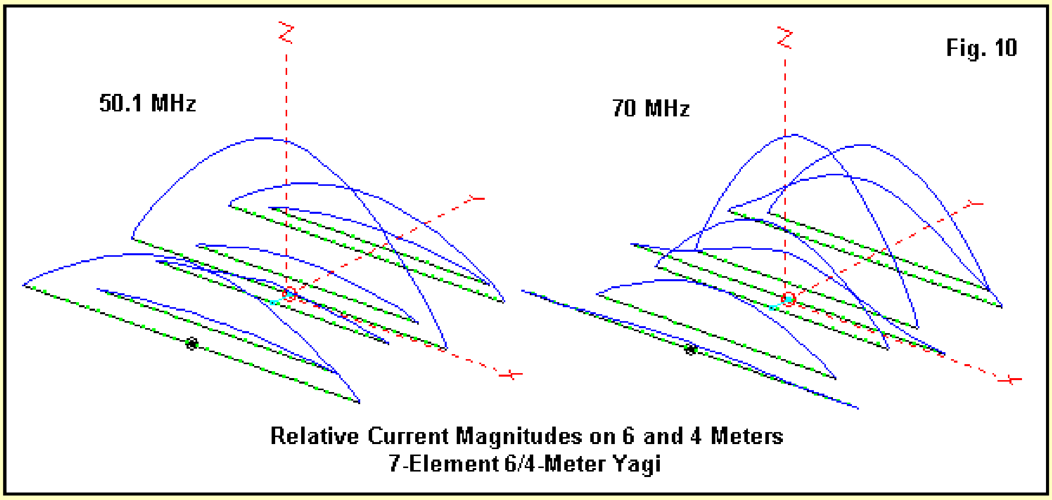


Fig. 10

Relative Current Magnitudes on 6 and 4 Meters
7-Element 6/4-Meter Yagi

If we examine the current magnitudes on the left portion of the figure, we can see a very large differential between current peaks on the longer 6-meter elements and the shorter 4-meter elements. However, the right side of the figure, for 4-meter operation, tells a different story. We see the peak currents on the short elements, but it is the longer ones that tell us about the design challenges. We might expect to see significant current on the 6-meter driver due to its direct connection to the feedline. However, notice that its curve has an odd shape compared to the curve we get when we use it on 6 meters, as the current tries to go to zero before it reaches the element end.

The directors are our primary focus. The first 70-MHz director shows a very high current level and in fact operates somewhat as a slaved 2nd driver for the array. Even more interesting is the 6-meter director, which has very significant current on it, even though dominated by the 4-meter director immediately ahead of it. One could make a case for adding a director behind the 6-meter director to "capture" the mutual coupling from the preceding director. However, since the array provided adequate performance without the missing director, I omitted it. (The added director will broaden the bandwidth and slightly increase the front-to-back ratio. Since 4 meters is such a narrow band, I let construction simplicity outweigh these small improvements. However, if you decide to experiment by modeling the array with an added 70-MHz director just short of the 6-meter director, you should be aware that the new director will requires adjustments to the length and spacing of nearly every element in the array.)

The following table provides the performance figures of the free-space model on both bands. I extended the limits of 4 meters to provide a sense of the operating passband on the higher frequency range.

. . . .

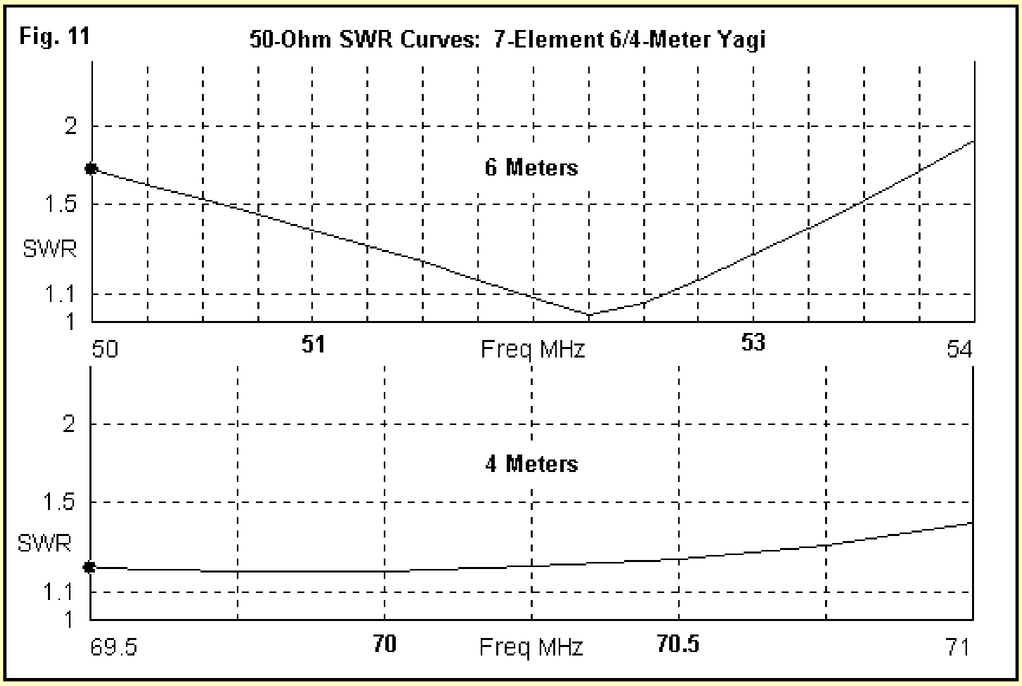
Performance of the 7-Element 6/4-Meter Yagi

Freq. MHz	Gain dBi	F-B dB	Feedpoint X R +/- jX Ohms	50-Ohm SWR
6 Meters				
50	7.14	16.3	41 - j 23	1.71
51	7.06	20.1	46 - j 15	1.38
52	7.09	21.4	50 - j 4	1.09
53	7.24	19.9	54 + j 11	1.26
54	7.49	16.6	59 + j 34	1.90
4 Meters				
69.5	7.72	14.3	48 - j 9	1.19
70	8.04	17.0	43 - j 4	1.18
70.5	8.40	17.9	41 - j 0	1.23
71	8.77	16.4	36 + j 1	1.40

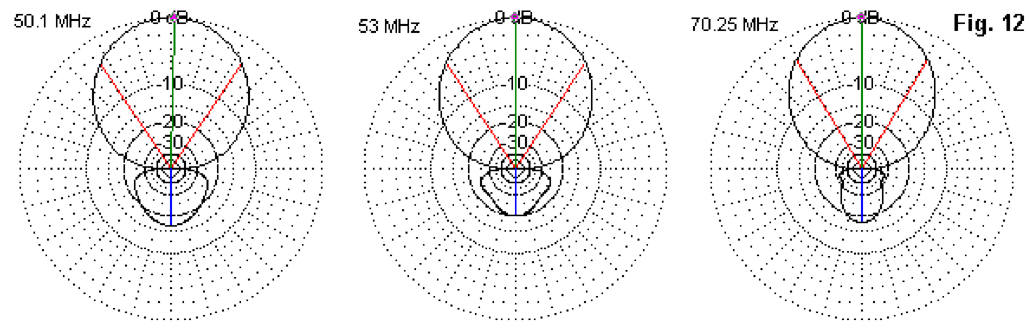
. . . .

For use only on the lower part of 6 meters, one may simply lengthen the 6 meter driver slightly to reduce the SWR in that region (and lose the upper end of the band). By changing only the driver length, we do not significantly change the gain and front-to-back along the band.

Note that, on 70-MHz, the gain and front-to-back ratio together oppose the progression of impedance rather than paralleling the impedance. This fact--natural to a slaved-driver system--makes adjustment of the upper band a good bit more finicky than the lower band. Any wholesale change in element diameter on 4 meters will require complete re-design of the array. Nevertheless, once set up, the operating bandwidth on both bands is very good, as evidenced by the 50-Ohm SWR curves shown in **Fig. 11**.



As well, the azimuth patterns for the array are quite well behaved, with patterns typical of a dual-band Yagi. See **Fig. 12** for some representative examples.



Representative Azimuth Patterns: 7-Element 6/4-Meter Yagi

There are no special notes for construction of the Yagi, since it follows standard handbook practices. The modeled dimensions presume that the elements are well insulated and isolated from a conductive boom. Hence, the plate technique shown for the 1-boom LPDA is completely adaptable to the Yagi.

However, mounting the array to a mast will present a challenge. The 6-meter driver and the surrounding 4-meter elements are at the center of the array. Rather than risk detuning the array--since the 4-meter elements are fairly sensitive--it may be better to place the boom-to-mast plate behind the driver assembly and to counter-weight the boom at the rear for balance.

So, which way should I go?

There are some who are drawn to LPDAs and some who are loyal to Yagis. Overall, on the two amateur bands, the Yagi is a slightly better performer, especially on 4 meters. However, it is also more sensitive on the 4-meter band and requires careful construction and field adjustment. The LPDAs should perform with no significant field adjustment except for finding the most desirable length of stub, so long as you use care in building the independent phase line for the 1-boom version. As well, the LPDAs provide good performance between the bands for receiving purposes.

In either case, if you develop a flipping mechanism to orient either array vertically for use with the FM protion of 6 meters, be sure to use a non-conductive mast. When the elements are close to and parallel with a conductive mast, you likely will expience severe detuning effects.

In the end, I shall leave the choice to your preferences. As well, there are undoubtedly many other antenna possibilities, including dual-band quads. Sometimes having too many choices can be worse than having none at all. . .

Model Descriptions of Antennas Cited in These Notes

1. LPDAs: Note: Element half-lengths appear in the Y column, with element spacing (from the longest element) recorded in the X column. All element lengths are tip-to-tip, and the center gaps are a part of the overall length.

50-70 8el t89 s06 11/3/03 8:45:45 AM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 51 MHz
Wire Loss: Aluminum (6061-T6) -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Conn.	Coord. (in) X	Y	Z	End 2 Conn.	Coord. (in) X	Y	Z	Dia (in)	Segs
1		0	-60.221	0		0	60.2208	0	0.5	25
2		13.8096	-53.593	0		13.8096	53.5926	0	0.5	23
3		26.0992	-47.694	0		26.0992	47.6939	0	0.5	19
4		37.0362	-42.444	0		37.0362	42.4445	0	0.5	17
5		46.7694	-37.773	0		46.7694	37.7728	0	0.5	15
6		55.4313	-33.615	0		55.4313	33.6154	0	0.5	13
7		63.1399	-29.915	0		63.1399	29.9155	0	0.5	13
8		70	-26.623	0		70	26.6228	0	0.5	11

Total Segments: 136

-------------- SOURCES --------------

No.	Specified Pos. Wire #	Specified Pos. % From E1	Actual Pos. % From E1	Actual Pos. Seg	Amplitude (V/A)	Phase (deg.)	Type
1	8	50.00	50.00	6	.70711	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Specified Pos Wire #	End 1 Specified Pos % From E1	End 1 Act % From E1	End 2 Specified Pos Wire #	End 2 Specified Pos % From E1	End 2 Act % From E1	Length (in)	Z0 (ohms)	VF	Rev/Norm
1	1	50.00	50.00	2	50.00	50.00	Actual dist	150	1	R
2	2	50.00	50.00	3	50.00	50.00	Actual dist	150	1	R
3	3	50.00	50.00	4	50.00	50.00	Actual dist	150	1	R
4	4	50.00	50.00	5	50.00	50.00	Actual dist	150	1	R
5	5	50.00	50.00	6	50.00	50.00	Actual dist	150	1	R
6	6	50.00	50.00	7	50.00	50.00	Actual dist	150	1	R
7	7	50.00	50.00	8	50.00	50.00	Actual dist	150	1	R

Ground type is Free Space
===============

50-70 10el t91 s05 11/4/03 4:38:47 AM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 70 MHz
Wire Loss: Aluminum (6061-T6) -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Conn.	End 1 X	End 1 Y	End 1 Z	End 2 Conn.	End 2 X	End 2 Y	End 2 Z	Dia (in)	Segs
1		0,	-60.221,	0		0,	60.2208,	0	0.5	25
2		10.8784,	-54.999,	0		10.8784,	54.9995,	0	0.5	23
3		20.8137,	-50.231,	0		20.8137,	50.2308,	0	0.5	21
4		29.8875,	-45.876,	0		29.8875,	45.8757,	0	0.5	19
5		38.1746,	-41.898,	0		38.1746,	41.8981,	0	0.5	17
6		45.7431,	-38.265,	0		45.7431,	38.2654,	0	0.5	17
7		52.6555,	-34.948,	0		52.6555,	34.9477,	0	0.5	15
8		58.9685,	-31.918,	0		58.9685,	31.9176,	0	0.5	13
9		64.7342,	-29.15,	0		64.7342,	29.1502,	0	0.5	13
10		70,	-26.623,	0		70,	26.6228,	0	0.5	11

Total Segments: 174

-------------- SOURCES --------------

No.	Specified Pos. Wire #	Specified Pos. % From E1	Actual Pos. % From E1	Actual Pos. Seg	Amplitude (V/A)	Phase (deg.)	Type
1	10	50.00	50.00	6	.70711	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Specified Pos Wire #	End 1 Specified Pos % From E1	End 1 Act % From E1	End 2 Specified Pos Wire #	End 2 Specified Pos % From E1	End 2 Act % From E1	Length (in)	Z0 (ohms)	VF	Rev/Norm
1	1	50.00	50.00	2	50.00	50.00	Actual dist	150	1	R
2	2	50.00	50.00	3	50.00	50.00	Actual dist	150	1	R
3	3	50.00	50.00	4	50.00	50.00	Actual dist	150	1	R
4	4	50.00	50.00	5	50.00	50.00	Actual dist	150	1	R
5	5	50.00	50.00	6	50.00	50.00	Actual dist	150	1	R
6	6	50.00	50.00	7	50.00	50.00	Actual dist	150	1	R
7	7	50.00	50.00	8	50.00	50.00	Actual dist	150	1	R
8	8	50.00	50.00	9	50.00	50.00	Actual dist	150	1	R

9	9	50.00	50.00	10	50.00	50.00	Actual dist	150	1	R

Ground type is Free Space

===============
50-70 12el t93 s04 11/3/03 8:46:48 AM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 51 MHz
Wire Loss: Aluminum (6061-T6) -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Conn.	Coord. (in) X, Y, Z	End 2 Conn.	Coord. (in) X, Y, Z	Dia (in)	Segs
1		0,-60.221, 0		0,60.2208, 0	0.5	25
2		8.97321,-55.914, 0		8.97321,55.9139, 0	0.5	23
3		17.3047,-51.915, 0		17.3047,51.9151, 0	0.5	21
4		25.0403,-48.202, 0		25.0403,48.2022, 0	0.5	19
5		32.2226,-44.755, 0		32.2226,44.7549, 0	0.5	19
6		38.8913,-41.554, 0		38.8913,41.5541, 0	0.5	17
7		45.0831,-38.582, 0		45.0831,38.5822, 0	0.5	15
8		50.8321,-35.823, 0		50.8321,35.8229, 0	0.5	15
9		56.1699,-33.261, 0		56.1699,33.2609, 0	0.5	13
10		61.1259,-30.882, 0		61.1259,30.8821, 0	0.5	13
11		65.7275,-28.674, 0		65.7275,28.6735, 0	0.5	11
12		70,-26.623, 0		70,26.6228, 0	0.5	11

Total Segments: 202

-------------- SOURCES --------------

No.	Specified Pos. Wire #	% From E1	Actual Pos. % From E1	Seg	Amplitude (V/A)	Phase (deg.)	Type
1	12	50.00	50.00	6	.70711	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Wire #	Specified Pos % From E1	End 1 Act % From E1	End 2 Wire #	Specified Pos % From E1	End 2 Act % From E1	Length (in)		Z0 (ohms)	VF Rev/Norm
1	1	50.00	50.00	2	50.00	50.00	Actual dist	150	1	R
2	2	50.00	50.00	3	50.00	50.00	Actual dist	150	1	R
3	3	50.00	50.00	4	50.00	50.00	Actual dist	150	1	R
4	4	50.00	50.00	5	50.00	50.00	Actual dist	150	1	R
5	5	50.00	50.00	6	50.00	50.00	Actual dist	150	1	R
6	6	50.00	50.00	7	50.00	50.00	Actual dist	150	1	R
7	7	50.00	50.00	8	50.00	50.00	Actual dist	150	1	R
8	8	50.00	50.00	9	50.00	50.00	Actual dist	150	1	R
9	9	50.00	50.00	10	50.00	50.00	Actual dist	150	1	R
10	10	50.00	50.00	11	50.00	50.00	Actual dist	150	1	R
11	11	50.00	50.00	12	50.00	50.00	Actual dist	150	1	R

Ground type is Free Space
=============
50-70 14el t94 s03 11/3/03 8:47:26 AM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 51 MHz
Wire Loss: Aluminum (6061-T6) -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No. End 1 Coord. (in) End 2 Coord. (in) Dia (in) Segs

Conn.	X	Y	Z	Conn.	X	Y	Z		
1	0,-60.221,	0		0,60.2208,	0	0.5	25		
2	7.63568,-56.556,	0		7.63568,56.5559,	0	0.5	23		
3	14.8067,-53.114,	0		14.8067, 53.114,	0	0.5	21		
4	21.5412,-49.882,	0		21.5412,49.8816,	0	0.5	21		
5	27.866,-46.846,	0		27.866,46.8459,	0	0.5	19		
6	33.8058,-43.995,	0		33.8058, 43.995,	0	0.5	19		
7	39.3841,-41.318,	0		39.3841,41.3176,	0	0.5	17		
8	44.623,-38.803,	0		44.623,38.8031,	0	0.5	15		
9	49.543,-36.442,	0		49.543,36.4416,	0	0.5	15		
10	54.1636,-34.224,	0		54.1636,34.2239,	0	0.5	15		
11	58.503,-32.141,	0		58.503,32.1411,	0	0.5	13		
12	62.5783,-30.185,	0		62.5783, 30.185,	0	0.5	13		
13	66.4056,-28.348,	0		66.4056, 28.348,	0	0.5	11		
14	70,-26.623,	0		70,26.6228,	0	0.5	11		

Total Segments: 238

-------------- SOURCES --------------

No.	Specified Pos.		Actual Pos.		Amplitude	Phase	Type
	Wire #	% From E1	% From E1	Seg	(V/A)	(deg.)	
1	14	50.00	50.00	6	.70711	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Specified Pos		End 1 Act	End 2 Specified Pos		End 2 Act	Length	Z0	VF	Rev/Norm
	Wire #	% From E1	% From E1	Wire #	% From E1	% From E1	(in)	(ohms)		
1	1	50.00	50.00	2	50.00	50.00	Actual dist	150	1	R
2	2	50.00	50.00	3	50.00	50.00	Actual dist	150	1	R
3	3	50.00	50.00	4	50.00	50.00	Actual dist	150	1	R
4	4	50.00	50.00	5	50.00	50.00	Actual dist	150	1	R
5	5	50.00	50.00	6	50.00	50.00	Actual dist	150	1	R
6	6	50.00	50.00	7	50.00	50.00	Actual dist	150	1	R
7	7	50.00	50.00	8	50.00	50.00	Actual dist	150	1	R
8	8	50.00	50.00	9	50.00	50.00	Actual dist	150	1	R
9	9	50.00	50.00	10	50.00	50.00	Actual dist	150	1	R
10	10	50.00	50.00	11	50.00	50.00	Actual dist	150	1	R
11	11	50.00	50.00	12	50.00	50.00	Actual dist	150	1	R
12	12	50.00	50.00	13	50.00	50.00	Actual dist	150	1	R
13	13	50.00	50.00	14	50.00	50.00	Actual dist	150	1	R

Ground type is Free Space
===============

2. Yagi: Note that the elements are grouped by band, with the 70-MHz elements shown first. Half-element lengths appear in the X column, with the spacing from the 6-meter reflector shown in the Y column. All element lengths are tip-to-tip, and the driver gaps are a part of the overall length.

6m/4m Yagi 11/3/03 8:49:13 AM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 70.25 MHz
Wire Loss: Aluminum (6061-T6) -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Coord. (in)			End 2 Coord. (in)			Dia (in)	Segs
Conn.	X	Y	Z	Conn. X	Y	Z		
(4-meter elements)								
1	-41.5,	10.5,	0	41.5,	10.5,	0	0.5	21
2	-40.5,	34,	0	40.5,	34,	0	0.5	21
3	-38.7,	48.5,	0	38.7,	48.5,	0	0.5	21
4	-38.5,	79,	0	38.5,	79,	0	0.5	21

(6-meter elements)
5 -58.4, 0, 0 58.4, 0, 0 0.5 31
6 -54.6, 40.7, 0 54.6, 40.7, 0 0.5 31
7 -47.9, 73.45, 0 47.9, 73.45, 0 0.5 31

Total Segments: 177

-------------- SOURCES --------------

No.	Specified Pos.		Actual Pos.		Amplitude	Phase	Type
	Wire #	% From E1	% From E1	Seg	(V/A)	(deg.)	
1	6	50.00	50.00	16	1	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Specified Pos		End 1 Act	End 2 Specified Pos		End 2 Act	Length	Z0	VF	Rev/Norm
	Wire #	% From E1	% From E1	Wire #	% From E1	% From E1	(in)	(ohms)		
1	2	50.00	50.00	6	50.00	50.00	Actual dist	100	1	N

Ground type is Free Space

Go to Main Index