3 More 14-30 MHz LPDA Designs

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In an earlier article ("Long-Boom LPDAs for 14-30 MHz"), I described the basic design of an idealized log-periodic dipole array (LPDA) for the 20-10 meter range. It had a free-space gain range of 8.7 to 9.0 dBi, with correspondingly high front-to-back figures. The 56' boom was not considered a hindrance for this "dream beam." The array used a Tau of 0.9500 and a Sigma of 0.0560 along with 22 elements to achieve its performance.

The design had some interesting features, designed to overcome some of the weaknesses of finite-length LPDAs. First, the value of Tau was circularized in the elements at each end of the array, resulting in a shortening of the very longest elements and a lengthening of the shortest elements. The result is an LPDA whose element ends describe a slight ogee curve. The "Tau-circularizing" technique tends to equalize gain at the passband ends relative to mid-band performance. However, it must be used with care so as not to unduly disturb the feedpoint impedance across the pass band.

Since the circularizing technique is most effective at the lower end of the passband, gain still tends to fall off at the upper end of the passband unless the shortest element is calculated as if the highest operating frequency was about 1.6 times its actual value. Such a high upper-end frequency limit adds a number of elements to the design, along with considerable boom length. Interestingly, early work on LPDAs in the 1960s recognized a "high frequency truncation coefficient," but failed to associate the idea with a clear notion of which elements in an LPDA are active. Early thinking led to the misconception that only the immediately adjacent elements to the one nearest resonance were active. In fact, virtually all elements forward of the most active element are themselves active and contribute to the pattern formation for a given frequency.

To effect the desired performance gain with fewer elements, the forward-most element was made parasitic and lengthened to form a director for the highest band (10 meters). The length and spacing for this element are selected to achieve the desired gain with least effect on the feedpoint impedance of the array at all other frequencies. The further away from the closest LPDA element, the higher the gain, but the lower the front-to-back ratio and the greater the disturbance to feedpoint impedance values.

These same design techniques can be applied to shorter-boom LPDAs with relatively equal success--subject only to limitations imposed by using fewer elements on a shorter boom. In this article, in addition to a quick review of the ideal LPDA for 20-10 meters, we shall examine designs using 16, 12, and 9 elements on 42, 32, and 21 foot booms respectively. The ideal design replicates 4-element monoband Yagi performance assuming a moderately long boom. The 16-element design provides close to long-boom 3-element monoband Yagi performance across the pass band--about 8 dBi free-space gain. The 12-element model gives us about 2-element quad or short-boom 3-element monoband Yagi performance--about 7 dBi across the passband. Finally, the shortest member of the family comes close to 2-element monoband reflector-driver Yagi performance--something close to 6 dBi free-space gain. When comparing the performance numbers to those of other types of arrays, remember that the LPDA provides performance both within and between the ham bands.

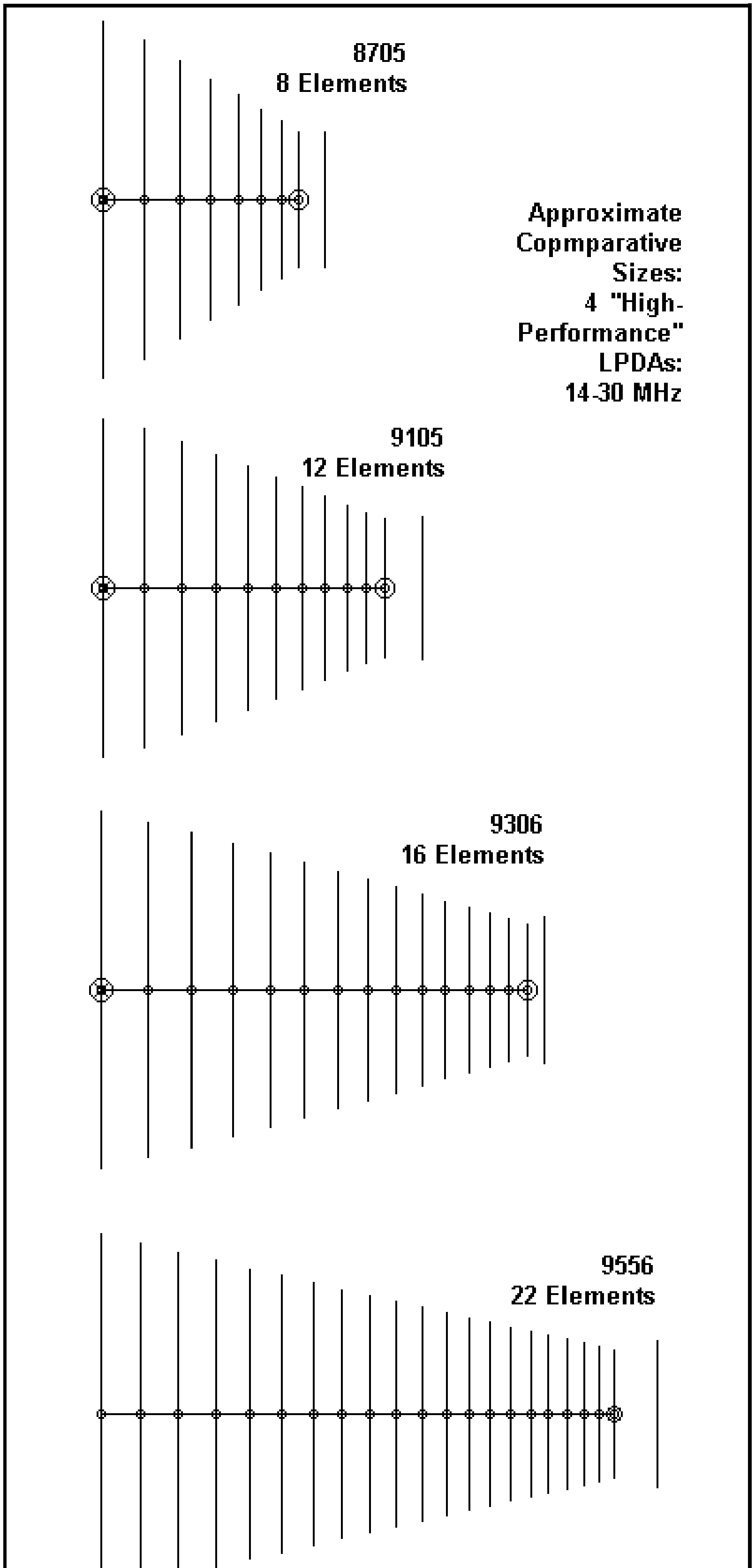
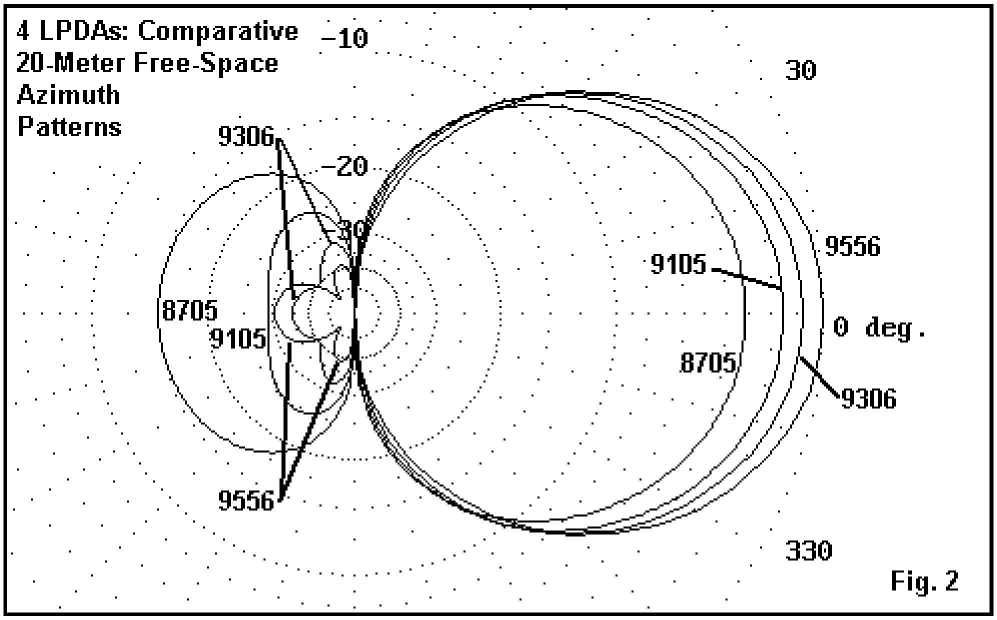


Fig. 1

Fig. 1 provides some comparative outline sketches of the 4 members of this LPDA family. There is little difference in the longest and shortest elements for each set, but considerable difference in total boom length, total weight, and performance. Note also that the position of the parasitic director has been selected by hand to optimize each design within the overall objectives for each.



In **Fig. 2**, we have the free-space azimuth patterns for the family members for the middle of the 20-meter band (14.175 MHz). The stepped gain differential is clearly apparent. The larger step downward in gain for the smallest LPDA is a function of the fact that the shorter the LPDA, the lower both Tau and Sigma go, mutually reducing gain potential for the array.

The rear lobes of an LPDA pattern in a very general way are the reciprocal of the forward lobes. The higher the forward gain, the higher the 180-degree front-to-back ratio. Once that ratio passes about 30 dB, we find variations in the rear pattern, even in the best controlled arrays. The rear may look like a single lobe, a three-lobe pattern with either the central or side lobes emphasized, or a small ripply blob. Although gain and front-to-rear performance are closely correlated, the natural variations in each over the full passband do not directly coincide.

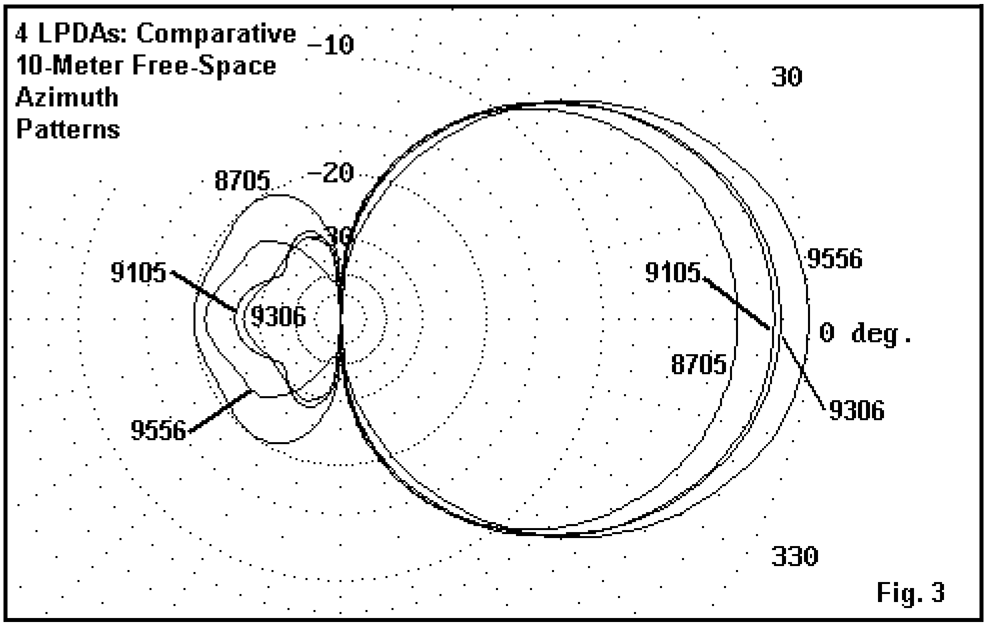


Fig. 3 shows the corresponding free-space azimuth patterns for 28.85 MHz. Here, we do not see the even stair-stepping of forward gain due to the variable treatment of the parasitic director. The highest gain model (9556) has a widely spaced director which reduces the front-to-back ratio to barely 20 dB. In contrast, the 16-element model (9306) shows considerably better rearward performance, but less relative forward gain--due to the close spacing of the director (see Fig. 1). The smallest two LPDAs in the collection (9105 and 8705) have relatively wide-spaced directors, although 9105 manages a higher gain than perhaps it needed for balance across the entire passband. However, as we shall see, it also shows the widest gain range across 10 meters.

In designing the members of this LPDA family, I set as a goal the equalization of high-end gain with mid-band gain (about 21 MHz) with acceptable feedpoint impedances and a 180-degree front-to-back ratio of 20 dB. Only in a couple of instances does the front-to-back ratio dip slightly below the target value.

The feedpoint impedance was selected to match either a 50-Ohm or a 75-Ohm system. In some designs, the use of 75-Ohm coaxial cable or a 75-to-50 Ohm balun transformer may yield lower SWR values than a direct 50-Ohm feed. The practical concern is not so much line losses, but the sensitivity of some equipment to SWR values above 1.5:1: some gear tends to reduce power or shut down at SWR values well below the traditional limit of 2:1. In all cases, for the low impedance feed system, the phase lines were set at a characteristic impedance (Zo) of 100 Ohms.

The designs were also tested--and modified, if necessary--for a phase line Zo of 250 Ohms. As we shall see, the higher phase-line impedance reduces gain performance slightly (0.1 to 0.15 dB on average), but results in an unconditionally stable array across the passband. The mid-point feed impedance ranges from 100 to 120 Ohms, and the arrays may be fed using a 2:1 broad-band transmission line transformer, such as one of those designed by W2FMI, Jerry Sevick, and available from Amidon. In general, the higher phase-line Zo results in a smoother SWR curve across the passband and a total absence of "spikes."

All of the family members use an idealized element diameter of 0.5". In general, the dimensions shown for each family member are satisfactory for all but the longest and shortest elements (including the parasitic director) in the arrays. Elements whose lengths have been adjusted for a parasitic function or in the course of circularizing Tau should be remodeled using the exact element diameter taper to be used the version constructed. In practical terms, this means remodeling the entire array with each element using its diameter taper. However, this necessary procedure may limit those who model LPDAs in NEC-2. The Leeson-correction system for linear elements using a tapered diameter schedule will only function on elements that are within about 15% of resonant length for the frequency being tested. Elements outside that range will not be corrected, and subtle errors in the modeled performance may result. Hence, NEC-4 would be the software of choice for final design modeling for the LPDAs in our family.

A Review of 9556

9556 is the ideal 56' long LPDA which we have examined in the past. The following table gives the overall element length and cumulative spacing for the design.

. . . .

Element #	Length (feet)	Spacing from Reflector (feet)
1	36.05	-----
2	34.17	4.02
3	32.33	7.83
4	30.73	11.45
5	29.20	14.89
6	27.74	18.16
7	26.35	21.27
8	25.03	24.22
9	23.78	27.03
10	22.59	29.69
11	21.46	32.22
12	20.39	34.62
13	19.37	36.91
14	18.40	39.08
15	17.48	41.14
16	16.61	43.10
17	15.78	44.96
18	14.99	46.72
19	14.24	48.40
20	13.53	50.00
21	12.85	51.51
22	14.78/14.60	55.83 Director: See text.

. . . .

The two lengths listed for the director apply to the different values of phase-line Zo: the longer director applies to the 100-Ohm line, while the shorter applies to the 250-Ohm line. The change in length was necessitated to optimize--so far as possible--the gain and SWR curves on 10 meters.

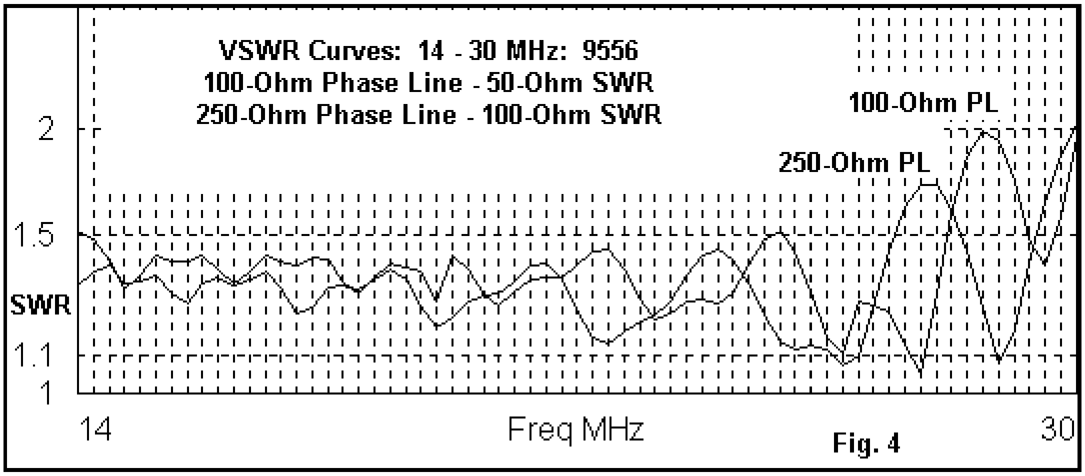


Fig. 4

Fig. 4 shows the SWR curves for the entire passband, taken at 0.25 MHz intervals. The interval is sufficiently small to show signs of performance instability, and none appear with either choice of phase line Zo. In fact, the design does not require the use of a shorted transmission line stub behind the longest element, although one may be added to set all of the elements at the same DC value. Something of about 450-600 Ohms characteristic impedance and a length of about a foot should do the job with minimal disturbance to the performance curves. When both Tau and Sigma together reach a certain level--obtained in this design--a stub is not necessary to control or remove impedance and performance spikes.

The anticipated performance of the array for each value of phase line Zo is listed in the following tables.

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9556143X: 22 elements (21 LPDA + 1 par): 55.83' boom: 0.5" dia.
Tau = 0.9500; Sigma = 0.0560: ogee'd: TL = 100 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	50-Ohm VSWR	75-Ohm VSWR
20					
14.0	8.85	24.84	75.6 + j 0.2	1.51	1.01
14.175	8.85	30.28	74.2 - j 3.5	1.49	1.05
14.35	8.81	39.01	71.9 - j 6.5	1.46	1.10
17					
18.118	8.83	38.18	67.2 - j 7.0	1.38	1.16
15					
21.0	8.72	42.61	64.7 + j 0.1	1.29	1.16
21.225	8.71	41.67	66.9 - j 0.5	1.34	1.12
21.45	8.72	41.04	67.2 - j 1.8	1.35	1.12
12					
24.94	8.81	32.04	73.2 - j 2.2	1.47	1.04
10					
28.0	8.92	24.94	72.3 + j16.5	1.58	1.26
28.85	9.04	21.29	47.3 - j30.7	1.87	1.98
29.7	9.05	19.57	50.2 + j20.9	1.51	1.69

Delta Gain: 0.34 dB

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9556143Y: 22 elements (21 LPDA + 1 par): 55.83' boom: 0.5" dia.

Tau = 0.9500; Sigma = 0.0560: ogee'd: TL = 250 Ohms
(Parasitic length revised for 250-Ohm TL: from +/-7.392 to +/-7.3)

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	100-Ohm VSWR
20				
14.0	8.68	26.48	131.1 - j 5.5	1.32
14.175	8.68	30.95	134.1 - j 3.9	1.34
14.35	8.69	34.01	137.6 - j 8.2	1.39
17				
18.118	8.71	47.27	130.3 - j 9.4	1.32
15				
21.0	8.79	36.30	130.3 - j11.9	1.33
21.225	8.81	34.27	132.2 - j18.4	1.38
21.45	8.80	33.29	127.4 - j26.1	1.40
12				
24.94	8.63	32.78	98.7 - j21.6	1.24
10				
28.0	8.76	25.63	82.1 - j39.7	1.61
28.85	8.66	25.92	102.0 - j 7.5	1.08
29.7	8.83	22.34	70.1 - j40.9	1.82

Delta Gain: 0.20 dB

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Since both models are stable across the entire passband, the choice of phase line Zo value is optional with the builder. Note that the average gain of the model with the higher Zo is about 0.15 dB lower than for the model using a 100-Ohm line. However, the 250-Ohm line model shows a lower variation in gain across the pass band.

9306: 16 Elements on a 42' Boom

If 9556 is unrealistic for all but a hand full of builders, 9306 might appeal to perhaps a double handful of antenna constructors. The 42' boom is somewhat less daunting, but should not be underestimated for its support complexity. As well, the 16 elements carry considerable raw weight and wind load. Nonetheless, the array comes close to providing full 3-element monoband performance from 14 to 30 MHz.

The following table provides dimensions.

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Element #	Length (feet)	Spacing from Reflector (feet)
1	35.80	-----
2	33.80	4.43
3	31.70	8.55
4	29.60	12.38
5	27.60	15.94
6	25.67	19.25
7	23.87	22.33
8	22.20	25.20
9	20.65	27.86
10	19.20	30.34
11	17.86	32.64
12	16.61	34.79

13	15.45	36.78	
14	14.36	38.63	
15	13.36	40.36	
16	14.70/14.20	41.96	Director: See text.

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Regardless of the choice of phase line Zo, the design uses a 0.5' long shorted stub with a 600-Ohm characteristic impedance. Fig. 5 will show why the stub--optional on the big brother of this LPDA--is necessary here.

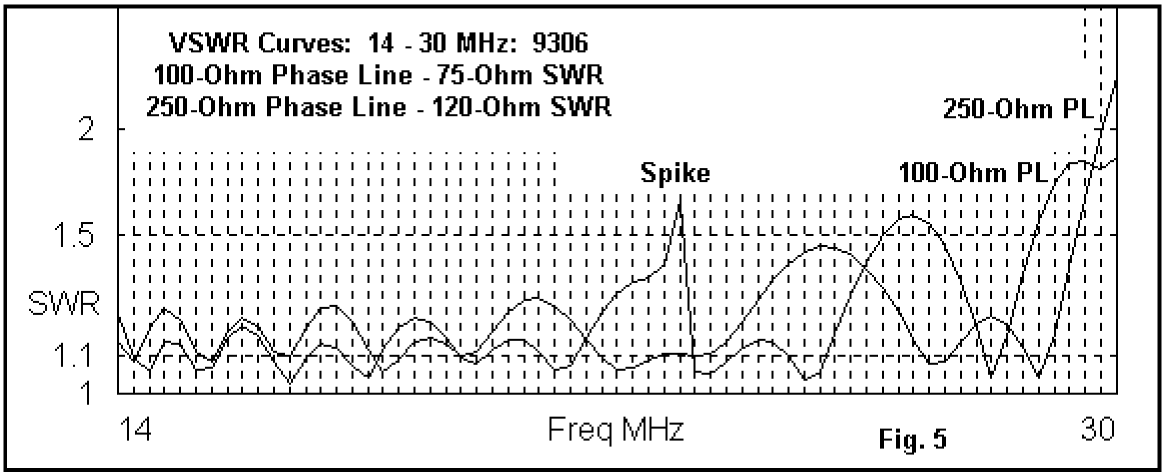

Fig. 5

The SWR curves for two versions of the LPDA appear in **Fig. 5**. The 100- Ohm phase line curve uses the 75-Ohm SWR because it shows smaller excursions than the corresponding 50-Ohm line. However, either feedline would be quite usable.

The 250-Ohm phase line model is completely stable. However, the 100-Ohm line model shows a spike at about 23 MHz. The impedance spike actually peaks narrowly at 22.95 MHz with an SWR that is greater than 4:1 and a reduction in gain to under 6 dBi. The front-to-back ratio is less than 10 dB. Such a narrow spike, well outside of the amateur bands, may be acceptable for some builders, not for others, depending upon the design specifications one sets for the array.

Within the ham bands, the performance of the array in both versions can be summarized in two tables.

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9306Q16: 16 elements (15 LPDA + 1 par): 41.96' boom: 0.5" dia.
Tau = 0.9300; Sigma = 0.0600: ogee'd: TL = 100 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	50-Ohm VSWR	75-Ohm VSWR
20					
14.0	8.08	28.78	61.5 + j 3.3	1.24	1.23
14.175	8.07	33.97	67.2 + j 5.1	1.36	1.14
14.35	8.05	39.35	72.3 + j 1.4	1.45	1.04
17					
18.118	8.06	33.96	74.0 - j 5.2	1.49	1.07
15					
21.0	8.02	37.06	70.9 - j 1.0	1.42	1.06
21.225	8.03	36.56	72.8 - j 4.3	1.47	1.07
21.45	8.03	36.38	71.8 - j 8.6	1.47	1.13

12					
24.94	8.00	40.49	71.5 + j 1.3	1.43	1.05
10					
28.0	7.77	27.28	72.1 + j 0.4	1.44	1.04
28.85	7.93	25.88	47.7 - j11.1	1.26	1.63
29.7	8.15	20.55	56.0 + j33.3	1.88	1.79

Delta Gain: 0.38 dB

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9306P16: 16 elements (15 LPDA + 1 par): 41.96' boom: 0.5" dia.
Tau = 0.9300; Sigma = 0.0600: ogee'd: TL = 250 Ohms
(Parasitic length revised for 250-Ohm TL: from +/-7.35 to +/-7.1)

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	120-Ohm VSWR
20				
14.0	7.95	31.96	126.2 - j15.3	1.14
14.175	7.97	34.68	126.4 - j 7.5	1.08
14.35	7.99	38.02	133.4 - j 2.5	1.11
17				
18.118	7.90	335980	119.7 - j 9.1	1.08
15				
21.0	7.91	38.50	116.2 - j26.3	1.25
21.225	7.86	39.66	112.2 - j20.9	1.21
21.45	7.82	40.10	111.6 - j14.8	1.16
12				
24.94	7.83	32.41	112.4 - j41.0	1.43
10				
28.0	7.70	31.41	104.5 - j15.5	1.22
28.85	7.85	27.78	126.6 + j 5.1	1.07
29.7	7.81	23.33	137.3 - j82.3	1.90

Delta Gain: 0.29 dB

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The 250-Ohm phase line version of the 16-element LPDA shows a gain deficit of about 0.15 dB on average relative to the 100-Ohm phase line version. In exchange for the reduced gain, the builder obtains a completely stable array, with no weaknesses. In general, the lower the phase-line Zo, the greater the tendency to have one or more weaknesses in the overall performance curve, and these are generally signaled by a spike in the SWR curve. However, the SWR spike maximum and the greatest disturbance to performance may not occur at precisely the same frequency. However, they will be overlapping phenomena within 100 kHz or so.

The higher the values of both Tau and Sigma--resulting in a higher number of elements and a longer boom--the narrower that a spike will be. The use of the stub can reduce either the number or severity of a spike, as well as control its frequency. In this case, the spike was moved to a frequency that is generally harmless in terms of amateur operations. As the values of Tau and/or Sigma are reduced, the chief protection from spikes becomes a higher phase line Zo.

9105: 12 Elements on a 32' Boom

The next step down the ladder in our family of LPDAs is a 12-element model on a 32' boom. The dimensions of the array appear in the following table.

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Element #	Length (feet)	Spacing from Reflector (feet)	
1	36.00	-----	
2	34.00	4.15	
3	31.30	7.93	
4	28.47	11.36	
5	25.90	14.48	
6	23.55	17.33	
7	21.42	19.93	
8	19.47	22.28	
9	17.70	24.43	
10	16.10	26.38	
11	14.63	28.15	
12	15.17	32.00	Director: See text.

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For this design, it was unnecessary to alter the length of the director to obtain acceptable results with both the 100-Ohm and 250-Ohm phase lines. The design does use a 1' 450-Ohm Zo shorted stub on the rear of the boom. However, as we shall see, this stub can reduce and/or move weaknesses that appear in the 100-Ohm phase line model, but it cannot eliminate "spikes" altogether.

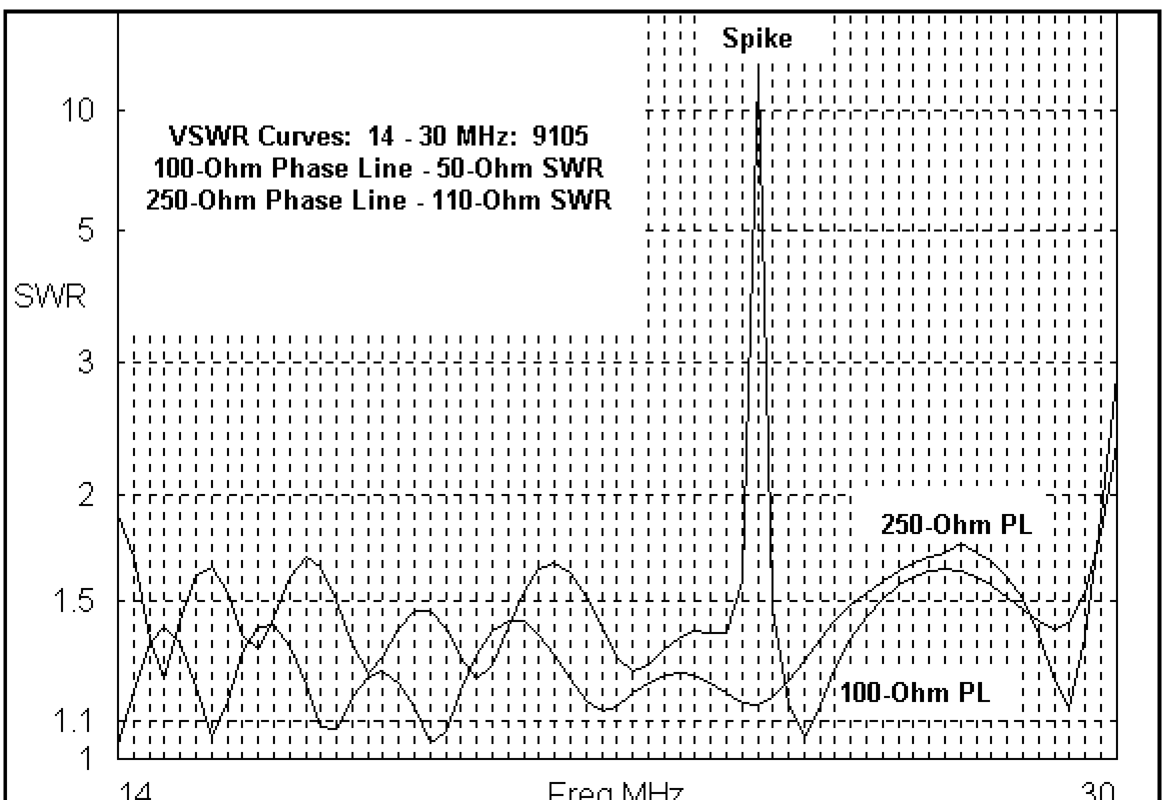


Fig. 6

Fig.6 shows the 50-Ohm SWR with the 100-Ohm phase line and the 110-Ohm SWR with the 250-Ohm phase line. As we reduce the number of elements and boom length--with a correspondingly reduced value of Tau--we should note larger excursions of SWR, regardless of the phase line value. The excursions are interesting, if we also track the changes of resistance and reactance along the way. Maximum values of capacitive and inductive reactance tend to occur when the resistance value is near its mean, while reactance tends to go to zero when the resistive component of the feedpoint impedance is at a high or low. Excursions of reactance are smaller with higher values of Tau and Sigma (together): hence, the SWR changes are smaller. As we shorten the boom and reduce Tau, the reactance undergoes a wider range of values.

The spike in the 50-Ohm curve in **Fig. 6** is also more extreme than the one in **Fig. 5**. It is both higher--exceeding an SWR of 10:1--and wider, covering nearly a half MHz. **Fig. 7** shows the worst-case azimuth pattern, in which the pattern technically reverses direction.

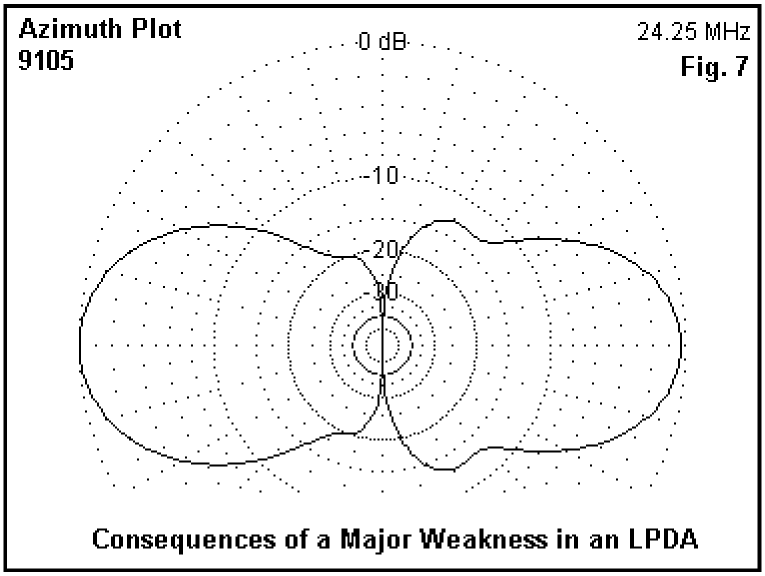
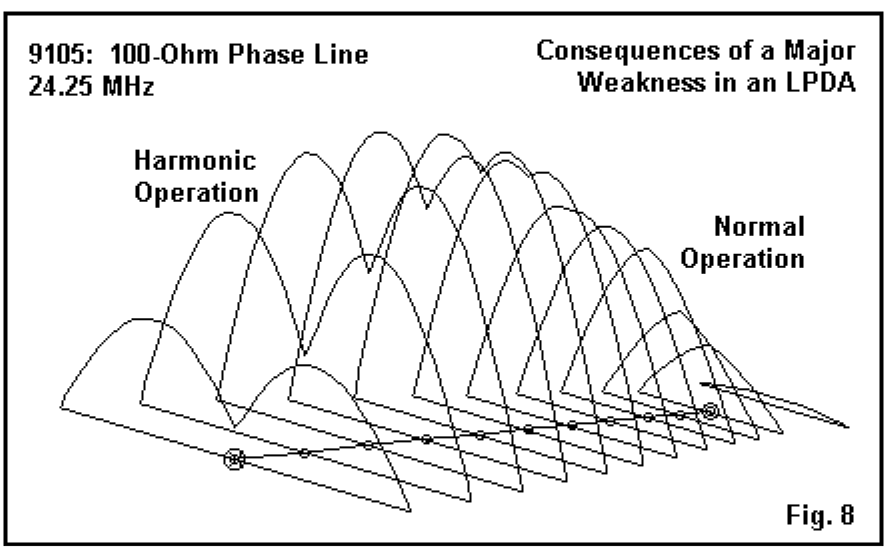


Fig. 8 shows why. Virtually all of the elements to the rear of the active one are also active, but in a harmonic mode, as indicated by the "double-hump" curves that register the current magnitude. This example is especially interesting, since in most cases, not all of the rear elements will be so active.



The following two tables provide the anticipated performance of the 12- element array.

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91051431: 12 elements (11 LPDA + 1 par): 32.000' boom: 0.5" dia.
Tau = 0.9099; Sigma = 0.0550: ogee'd: TL = 100 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	50-Ohm VSWR	75-Ohm VSWR
20					
14.0	7.33	32.93	94.6 - j 1.8	1.89	1.26
14.175	7.30	27.52	84.5 + j 5.7	1.78	1.26
14.35	7.25	24.91	71.0 - j16.0	1.55	1.25
17					
18.118	7.19	26.48	62.7 - j 0.2	1.25	1.20
15					
21.0	7.24	24.86	82.5 - j 5.4	1.66	1.12
21.225	7.26	25.85	78.2 - j11.9	1.62	1.17
21.45	7.28	27.19	71.8 - j14.3	1.54	1.22
12					
24.94	7.19	24.57	47.7 + j 1.1	1.05	1.57
10					
28.0	7.57	27.68	41.4 - j18.6	1.56	1.97
28.85	7.69	24.26	35.6 + j 1.6	1.41	2.11
29.7	8.01	19.95	70.6 + j25.9	1.73	1.43

Delta Gain: 0.82 dB

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91051431: 12 elements (11 LPDA + 1 par): 32.000' boom: 0.5" dia.
Tau = 0.9099; Sigma = 0.0550: ogee'd: TL = 250 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	110-Ohm VSWR
20				
14.0	7.12	26.83	106.2 - j 0.8	1.04
14.175	7.07	25.63	117.2 + j11.7	1.13
14.35	7.03	24.90	134.2 + j14.2	1.26
17				
18.118	7.02	25.95	131.3 - j15.8	1.25
15				
21.0	7.20	27.91	107.7 - j28.8	1.30
21.225	7.18	28.71	105.2 - j21.9	1.23
21.45	7.15	29.10	106.2 - j16.4	1.17
12				
24.94	7.20	27.34	138.9 + j 6.0	1.26
10				
28.0	7.38	28.70	70.4 - j22.4	1.66
28.85	7.52	26.51	84.3 - j 6.0	1.31
29.7	7.89	20.33	113.4 - j63.3	1.75

Delta Gain: 0.88 dB

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Performance of the 250-Ohm phase line model is down about 0.14 dB from the 100-Ohm phase line model. However, the 250-Ohm version is stable across the entire passband.

8705: 9 Elements on a 21' Boom

The final member of the LPDA family is the shortest--only 21' in boom length (plus a little excess for element mounting fixtures). As well it has the least number of elements--9--and the lowest value of Tau--0.8688. Indeed, these values are about the least that I would recommend for satisfactory performance, if we define that term as being close to the performance of a 2-element reflector-driver monoband Yagi. Even so, we shall discover that the low values used in the design of the LPDA yield the highest fluctuations in performance.

The dimensions for the 9-element array are as follows.

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Element #	Length (feet)	Spacing from Reflector (feet)	
1	36.00	-----	
2	32.30	3.89	
3	28.06	7.26	
4	24.38	10.19	
5	21.18	12.74	
6	18.40	14.96	
7	15.98	16.88	
8	13.89	18.55	
9	13.60	21.00	Director: See text.

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Both designs employ a stub. In both cases, a 1.9' shorted length of 450-Ohm transmission line or its equivalent is sufficient to tame the design.

As with the 12-element model, the 9-element design requires no change in the length of the director as we move from a 100-Ohm phase line to a 250-Ohm version. However, the spike which we might anticipate in the 100-Ohm phase line model shows itself vividly in **Fig. 9**, the SWR curves for both phase lines across the entire passband. The spike is higher and wider (with respect to frequency) than any other so far encountered. SWR values higher than 2:1 extend from abut 26.25 to 27.5 MHz.

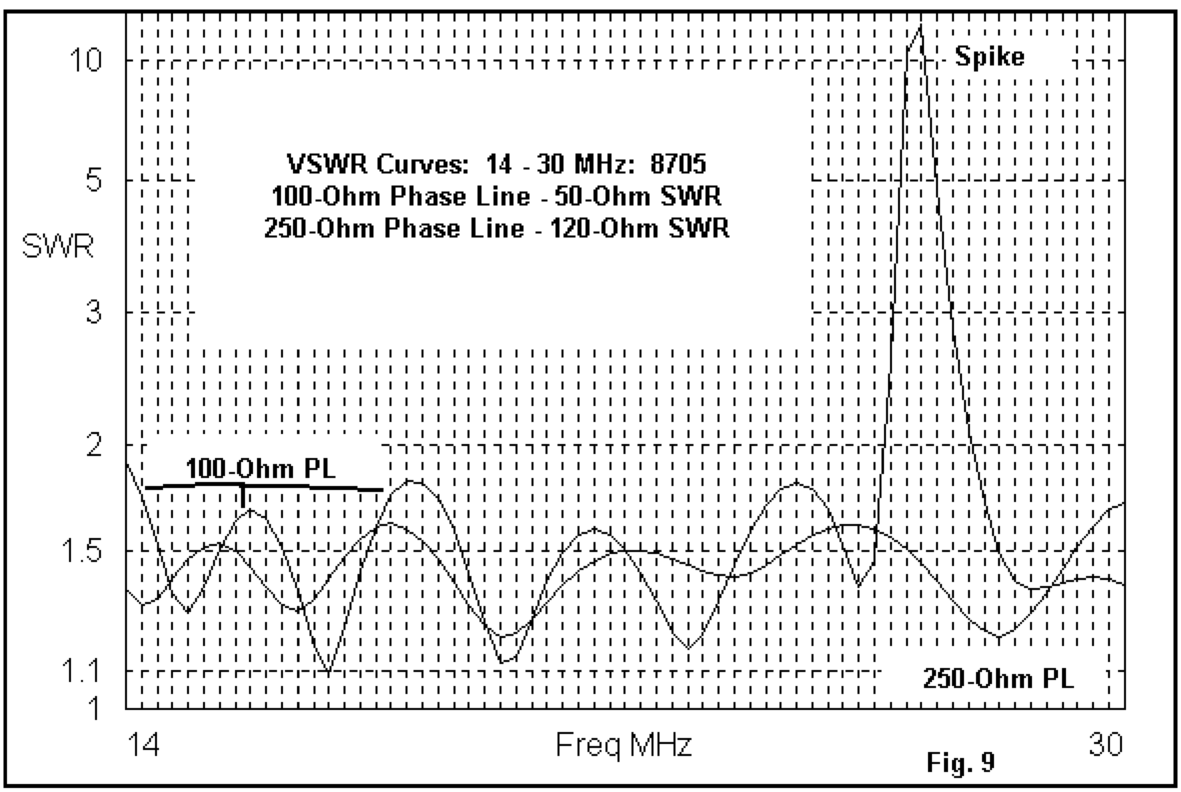

Fig. 9

Although the spike in the 100-Ohm phase line model is located well outside the amateur bands, it does interfere with operation of the array on the Citizen's Band. In contrast, the 250-Ohm phase line model permits operation throughout the passband.

Amateur band performance of both models appears in the following tables.

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8705B: 8 elements (7 LPDA + 1 par): 21.000' boom: 0.5" dia.
Tau = 0.8688; Sigma = 0.0523: ogee'd: TL = 100 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	50-Ohm VSWR	75-Ohm VSWR
20					
14.0	5.63	11.20	82.3 - j27.4	1.91	1.43
14.175	5.74	11.88	67.4 - j29.4	1.79	1.53
14.35	5.83	12.43	55.4 - j26.0	1.65	1.65
17					
18.118	6.03	14.13	66.3 + j25.1	1.67	1.46
15					
21.0	6.33	15.06	61.5 + j19.2	1.49	1.41
21.225	6.30	15.10	69.5 + j17.6	1.56	1.29
21.45	6.26	15.18	76.1 + j11.8	1.58	1.17
12					
24.94	6.13	18.10	67.2 + j29.5	1.79	1.53
10					
28.0	6.03	18.21	61.4 - j19.0	1.49	1.41
28.85	6.17	17.05	64.6 - j10.4	1.37	1.23
29.7	6.24	17.36	61.1 - j14.7	1.39	1.35

Delta Gain: 0.70 dB

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8705C: 8 elements (7 LPDA + 1 par): 21.000' boom: 0.5" dia.
Tau = 0.8688; Sigma = 0.0523: ogee'd: TL = 250 Ohms

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms	120-Ohm VSWR
20				
14.0	5.55	10.69	93.6 - j18.8	1.36
14.175	5.61	11.07	91.7 - j 3.0	1.31
14.35	5.66	11.38	94.6 + j12.5	1.30
17				
18.118	6.09	13.58	168.3 - j48.3	1.61
15				
21.0	6.14	15.48	150.5 - j29.6	1.37
21.225	6.13	15.46	136.8 - j41.6	1.42
21.45	6.12	15.44	120.8 - j45.3	1.45
12				
24.94	6.26	17.22	159.2 - j47.0	1.55
10				
28.0	6.27	19.07	104.5 - j13.6	1.20
28.85	6.27	19.74	100.4 - j29.4	1.38
29.7	6.39	22.64	80.6 - j31.2	1.66

Delta Gain: 0.84 dB

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The average gain of the two arrays across the entire passband is about the same. However, the 250-Ohm phase line version begins with lower gain on 20 meters and ends with higher gain on 10 meters. As well, relative to longer members of the array family, the 20-meter gain is in both cases below the array average--a result of decreasing the value of Tau below about 0.9. Most LPDAs with Tau values below about 0.9 and with Sigma values in the 0.04 to 0.06 range tend to show decreasing gain at the low end of the spectrum.

Nonetheless, the array provides serviceable performance a cross the design passband--about as good as a 20' long LPDA can do with elements that average 0.5" in diameter. Increasing the average element diameter can improve gain somewhat, with the most needed increase on 20 meters. Since most implementations of this or similar designs would have equivalent element diameters larger than 0.5" for the longest elements, we can expect some natural improvement to 20 meter performance as a matter of course.

Conclusion

The goal of this design exercise was to produce a family of LPDAs with relatively smooth performance across the entire design passband from 14 to 30 MHz. By the judicious use of standard LPDA modification techniques, the goal has been achieved, although before construction can begin, the designs would need to be customized to the element diameter taper schedule actually used.

Since small changes of construction may move the spike frequencies that occur on the smaller members of the family, the use of the 250-Ohm phase line--or something similar, may be the surest route to a successful building project. The average loss of 0.15 dB forward gain is unlikely to be noticed in operation. Because low-loss wide-band 2:1 transmission line transformer baluns are available, the higher feedpoint impedance natural to the high impedance phase line should present no problems. In fact, with the smaller version of the array, the higher natural feedpoint impedance may reduce SWR excursions.

Further LPDA construction details can be found in various handbooks, most notably, Chapter 10 of the latest ARRL Antenna Book. Since this is a basic design study, I shall forego construction details altogether. The object has been to show what is possible. The 4 LPDA family members do that well enough to encourage those interested to perfect the designs for particular building circumstances.