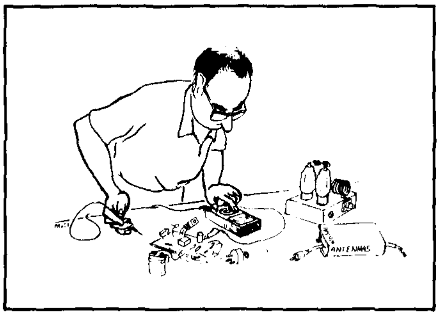
Ham Radio Techniques



Bill Orr, W6SAI

THE LOG PERIODIC ANTENNA FAMILY

Bill Orr, W6SAI

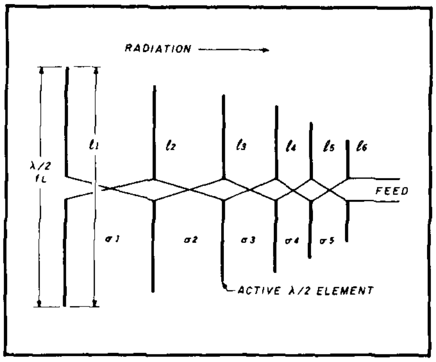
In 1957, D. E. Isbell and R. H. DuHamel published papers on the design of log periodic (LP) antennas.[1,2] There was a flurry of interest among Radio Amateurs, who adapted some interesting VHF LP antennas from the original design. But it wasn't until 1973, when the log periodic dipole (LPD) array was published by P. D. Rhodes,[3] that this class of antenna became practical for HF Amateur use.

Now that two new ham bands are available at 18 and 24 MHz, interest in the log periodic antenna is growing. How else can an active Amateur cover five bands? (How about a center-fed Zepp? — NX1G). The log periodic *antenna's principal virtue is that it can* cover a frequency span of 2:1, or more, while maintaining good power gain and front-to-back ratio over the whole range.

The log periodic dipole beam shown in **Figure 1** is a popular configuration for VHF television antennas. It's also used on the VHF/UHF ham bands. The pattern is directed toward the apex. The bandwidth of operation can be roughly defined as the frequencies at which the outer dipole elements are about one-half wavelength long. The element lengths and the relative spacing δ are arranged in a geometric progression with a taper factor τ.

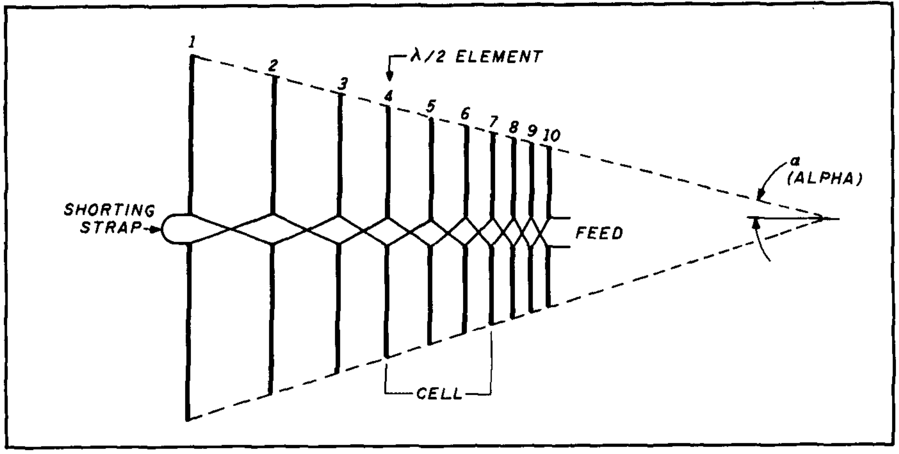
The dipoles are fed at their centers from a parallel wire transmission line transposed in such a way that successive dipoles are 180 degrees out of phase. A *broadband structure* is formed, with most of the radiation coming from those elements which are about a half wavelength long at the operating frequency. In a ten-element log periodic antenna that covers a 2:1 frequency span; perhaps only four of the ten elements are active at a given frequency within the operating range (see **Figure 2**). *The shorter than resonance* elements tend to act as directors and the longer than resonance elements as reflectors. The current distribution in the structure is such that only a "cell" (active region) of elements is active on a given frequency. The cell of active elements moves back and forth along the array as the operating frequency is changed. The gain and bandwidth thus bear a definite relationship to the length and included angle of the structure. The smaller the

FIGURE 1



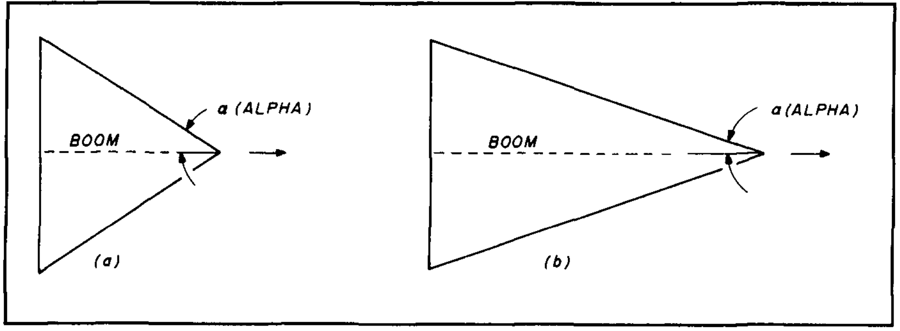
A six-element LPD beam. Element spacing (δ) and element length (λ) are determined by design factors, the longest element (λ) being about a half wavelength at the lowest operating frequency (fl).

FIGURE 2



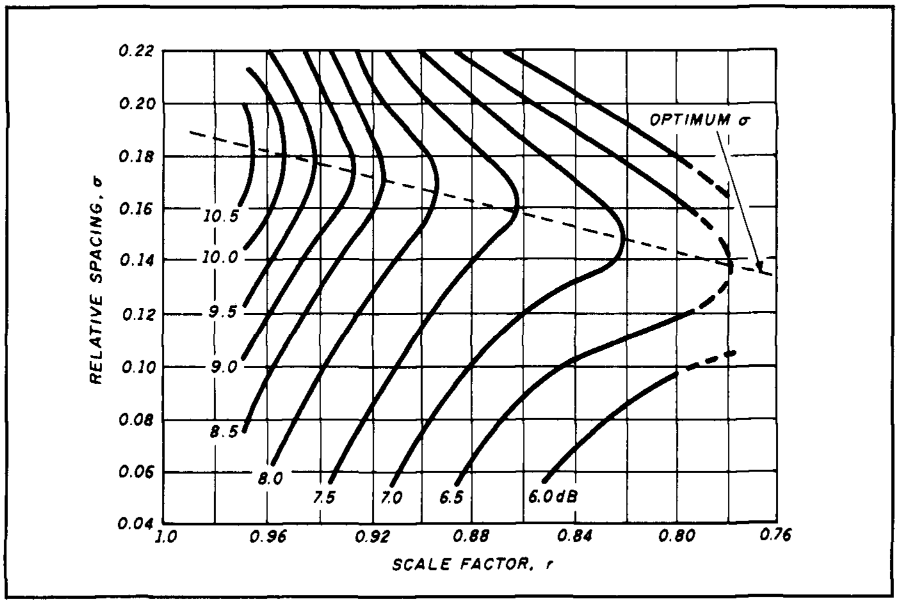
Log periodic active region (cell) encompasses elements a half wave long and a few shorter elements. Other elements have small induced currents and are not major contributors to the radiated energy. Shorting strap on longest element improves front-to-back ratio.

FIGURE 3



Increase in boom length and decrease in apex angle (α) *mean more elements in a cell and increased gain. A greater frequency span also requires a longer boom (B). High gain on a short boom (A) restricts frequency span.*

FIGURE 4



Reproduction of graph showing corrected gain figures for LPD array. Graph is in *Antenna Engineering Handbook, Johnson and Jasik, First Edition, pages 14-28. (Illustration courtesy Gary Breed, K9AY, Editor, RF Design magazine.)*

included angle the more elements in a cell, the longer the antenna, and the higher the power gain. (See **Figure 3**.)

The HF log periodic dipole antenna

Antenna boom length is of secondary importance in the VHF region, where a high gain, wide bandwidth log periodic array can be constructed on a boom about one or two wavelengths long. But because of the large size of the antenna, things begin to get out of hand quickly when you consider HF operation.

LPD array gain can be expressed in terms of the number of elements in the cell, the relative element spacing, and the scaling factor used. In general, power gains from 5.5 to 10.5 dBi (3.36 to 8.36 dBd) are the minimum and maximum gain limits of practical HF log periodic designs. (The larger arrays produce the higher gain figures.)

A representation of LPD antenna gain is expressed in Figure 4, Chapter 10 of *The ARRL Antenna Book*.[4] This chart was extracted from an early work of Carrel,[5] which was later found to provide inaccurate directive gain computations.[6] My **Figure 4** shows a corrected graph.

High gain LPD arrays are defined in the relative spacing region of 0.12 to 0.22 and large values of scaling factor (0.98 to 0.92). Unfortunately, these figures produce large array sizes that are almost impossible to achieve in an Amateur HF installation. One look at an HF LPD array at a military base quickly disproves the idea that a block-buster LPD rotary antenna can be placed in a typical backyard!

Practical HF LPD beams

However, all is not lost if those of us who use wideband LPD arrays are content to settle for a modest gain figure, while still retaining good front-to-back ratio and reasonable boom length. Ace Collins, K6VV, has described three LPD arrays (summarized in **Table 1**). These arrays can be built on boom lengths that approximate a single band Yagi beam.[7]

ATN Antennas of Birchip, Australia makes two commercial LPD beams that cover 13 to 30 MHz.* One design is on a 28-foot boom and has eight elements; another design covers the same range and has six elements on a 20-foot boom. The DJ2UT multiband antenna, built on a 20-foot boom, is a variation of the LPD design that covers 13 to 30 MHz.**

The ARRL Antenna Book (pages 10-5 and 10-6) describes a very small LPD design with a 10-foot boom that covers 18.06 to 29.7 MHz. It has just five elements and (according to the graph in **Figure 4**) provides only 3.2-dB gain over a dipole. It's doubtful that placing this amount of aluminum up in the air is worth the unspectacular power gain.

LPD power gain

You can compute the power gain of a LPD antenna from the design formulas and **Figure 4**. This figure can be expressed in terms of boom length for Amateur use in the HF region — much in the way it's done for conventional Yagi antennas. When compared on a band-by-band basis with a Yagi, the tradeoff of gain for bandwidth becomes apparent. For example, a three-element Yagi for 14 MHz provides about 6.5-dBd gain and is built on a 17-foot boom. At that boom length a typical 14 to 30-MHz LPD provides 3.5-dBd gain. The Yagi wins by 3 dB!

At 28 MHz, you can build an eight-element Yagi on a 45-foot boom which will provide nearly 10-dBd gain. An equivalent LPD on that boom provides only 7-dBd gain. The long Yagi wins by 3 dB.

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* ATN Antennas, 56 Campbell Street, Birchip 3486, Australia.

** Sommer GMBH, Kandelstrasse 35, D-7809 Denzlingen, F.R.G. Sommer Antennas, W4/DJ2UT, PO Box 847, Cowpens, SC 29330.

TABLE 1

Three LPY designs by K6VV (*QST,* November 1988). Shorting strap on longest element is 8" long. Average feedpoint impedance is 64 ohms. Design constant (τ) = 0.9, spacing constant (δ) = 0.05, average gain (from Figure 4) = 4.61 dBd.

	11-element array 13.5—30 MHz Boom = 25 feet		9-element array 17.5—30 MHz Boom = 16 feet		7-element array 20—30 MHz Boom = 12 feet	
Element number	Length feet	Spacing feet	Length feet	Spacing feet	Length feet	Spacing feet
1	36.44	3.64	28.94	2.78	24.53	2.45
2	32.80	3.28	26.05	2.50	22.08	2.21
3	29.52	2.95	23.44	2.25	19.87	1.99
4	26.57	2.66	21.10	2.03	17.89	1.79
5	23.91	2.39	19.00	1.82	16.10	1.61
6	21.52	2.15	17.09	1.64	14.49	1.45
7	19.37	1.94	15.38	1.48	13.04	-
8	17.43	1.74	13.84	1.33	-	-
9	15.69	1.57	12.46	-	-	-
10	14.12	1.41	-	-	-	-
11	12.71	-	-	-	-	-

The LPD array swaps bandwidth for power gain at any frequency, when compared with a Yagi of equivalent boom length. While the power gain figures of both types of antennas are approximate, the examples shown are indicative of the relative gain performance of these interesting antennas.

The LPD antenna has a couple of advantages. First, it allows a solid-state transmitter to operate efficiently over a wide frequency range without an antenna tuner. Second, it maintains its front-to-back characteristics over the complete operating range — something many Yagi designs can't do.

Is the tradeoff of power gain for bandwidth worth it? You'll have to answer that question yourself.

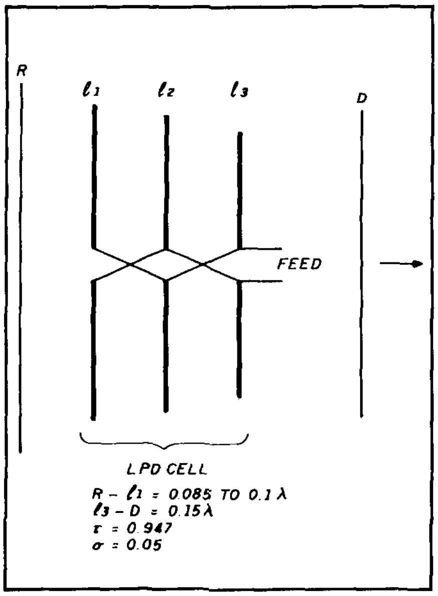
The log periodic Yagi (LPY) array

Peter Rhodes, K4EWG, and J. R. Painter, W4BBP, have described an interesting hybrid antenna.[8] It's designed for single band use, and combines an LPD cell with parasitic elements. The designers claim this configuration achieves higher gain and greater directivity over a single Amateur band than either an LPD or a Yagi array alone (see **Figure 5**). Best of all, these attributes are achieved with a boom comparable in length to that of a small Yagi. They claim a gain figure of 11.5 dBd for a 14-MHz LPY with a boom length of 26.5 feet. A four-element Yagi on the same boom would provide about 7.3-dBd gain. This gives an apparent signal advantage of about 4 dB for the LPY array over the Yagi. It sounds almost too good to be true!

The log periodic cell in the K4EWG/W4BBP LPY is designed for a single Amateur band, rather than a wide range of frequencies. A three-element log periodic cell provides a power gain of about 3 to 4 dBd over the design range. According to Leo Johnson, W3EB, adding a single reflector and a director provides another 4.5 dB.[9] If the gain figures are added, the resulting overall gain for the array is about 8.5 dBd. A second director boosts the gain an additional 1.5 dB, for a grand total of 10 dBd.

This agrees roughly with the gain figure proposed by K4EWB. Personally, I can't verify the gain of an LPY antenna. I know of no computer program that considers this antenna type and I'll reserve my judgment until somebody comes up with one. (I look forward to hearing from a programmer who can combine the virtues of the Yagi with the LP cell in one program and arrive at meaningful results.)

FIGURE 5



The log periodic Yagi design of K4EWG and W4BBP. Parasitic reflector and director(s) boost gain of LPY cell and improve front-to-back ratio.

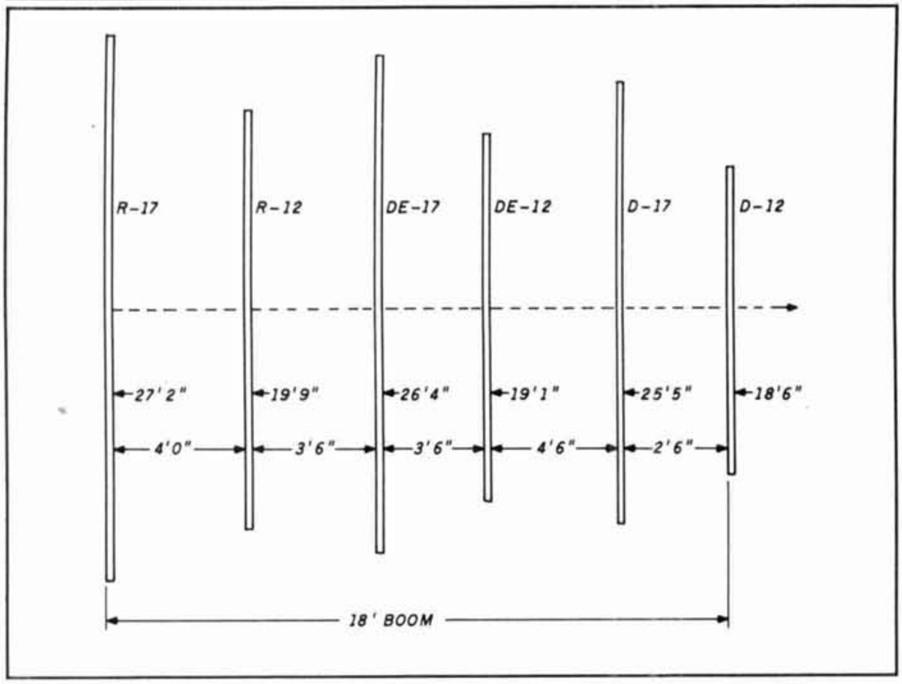
I must admit the LPY concept is tempting. I know that Burt, KV4AD, has a W3EB-type LPY beam on 12 meters, and I have heard his rock-crushing signal. **Photo A** shows a seven-element 10 to 30 MHz LP4 antenna. Perhaps I'll build one of these antennas and try it out on 10 meters. There's no substitute for experience!

A two band Yagi for 18/24 MHz

Brad Butcher, W9WPV, designed and built a two-band, interlaced, three-element array for 18 and 24 MHz. It's shown in **Figure 6**. The beams are built on an 18-foot boom and fed with separate gamma matches and coax lines. The SWR on each band is about 1.1:1; the front-to-back ratio on either band is better than 20 dB. You make your band selection at the operating position with a coax switch. This array, plus a conventional tribander, can provide coverage of the five popular HF bands with a minimum of fuss.

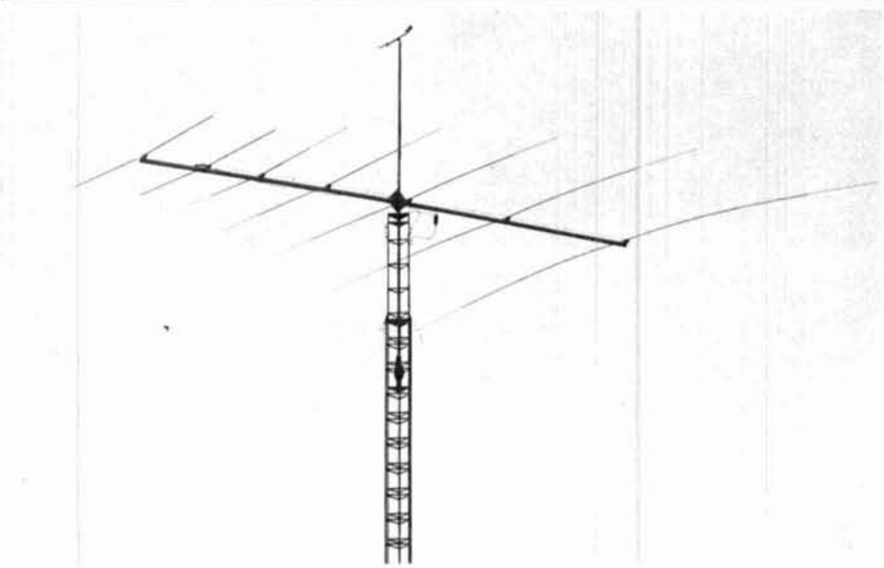
Did I hear someone ask about stacking this beam over a tribander on one tower? If I were to do this, I'd want at least 6 feet — and preferably 10 — between the antennas. Maybe some-

FIGURE 6



Dual Band (17/12 meter) beam of W9WPV. See August column for gamma match data. 17-meter gamma approximately 2'6" long. 12-meter gamma approximately 2'0" long.

PHOTO A



Seven-element LPY beam on 30-foot boom covers 10 to 30 MHz. Six-element cell plus director provides good gain and F/B ratio. Longest element is 42'9"; shortest element is 12'6". Director is 13'6-1/2". (Type KLM-10-30-7LP.)

one will try a stacking experiment to see how it works out!

The Dead Band Quiz

What with all the ionospheric fadeouts, solar storms, and summer lull in DX, there should have been plenty of time to solve the latest quizes. Many thanks to those who have written to me. I appreciate your comments and regret that I don't have the time to write and thank you all individually. I also appreciate your suggestions for future topics in this column!

The March quiz (the "black box") has several solutions. The simplest is a "star" of five 0.5-ohm resistors. Jack Cleary, N2JHS, and Curt Anderson, K3GCM, found this solution. Ed Clegg, W3LOY, pointed out that a "pentagon" of 1.25-ohm resistors would also do the job.

The April quiz dealing with coax lines was quickly solved by W9BTI, WB4HXE, W5DS, KC2KB, N3GDE, W2RJW, W4EIN, K7FC, W7FSP, KJ6GR, VE4KZ, WB6BYU, and WX4D. They knew that the impedance between the shields was zero. Replies are still coming in. I'll try to list them in my next column.

Thanks to all and 73! hr

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