three-band high-frequency log-periodic antennas

These three-band wire-beam log periodics for 20, 15 and 10 meters are inexpensive, easy to build and provide excellent performance

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Log-periodic antennas offer a number of operating advantages to the amateur who wants consistent contacts over long distances. Although there are several commercial rotatable high-frequency log periodics available on the market, they are large and complex, and home construction of a rotatable L-P is impractical for the average amateur. However, the same performance can be obtained from a light-weight wire log periodic which is fixed in one direction.

The log periodics described in this article are wire beams, so they are low cost and easy to build. The log-periodic antenna shown in **fig. 1** covers the frequency range from 14 to 30 MHz and can be used on the 10-, 15- and 20-meter bands. It can be erected in a 40- by 50-foot space and provides a minimum of 8-dB forward gain, a front-to-back ratio of 15 dB or more, and has low swr that is constant over each of the three amateur bands.

Although log periodics can be designed to cover a 10:1 frequency range, they are quite large. For this reason the antennas discussed in this article are limited to fixed, non-rotatable types for 20, 15 and 10 meters.

Since all details of log-periodic theory and design have been covered in previous articles, this data will not be repeated here.[1,2,3] I have put up a number of fixed log periodics in various directions, and for different frequency ranges, including L-Ps for 20, 15 and 10; 20 and 15; 15 and 10, and a big brute for 40, 20 and 15. All the L-Ps installed so far have provided excellent on-the-air performance.

At my station these antennas are suspended from tall pine and cedar trees, with the elements 45 to 50 feet above ground. All were originally beamed south so I could evaluate their performance rapidly with the rather consistent band openings I have to South and Central America.

The log-periodic antenna illustrated in **fig. 1** has an apex angle of approximately 36° ($\alpha=18^\circ$). If you want higher forward gain, and if space is available, the design in **fig. 2** has a minimum gain of 10 dB for each of the three bands. However, its overall length is 100 feet. This antenna has been in use at my station for the past year, and has done an excellent job.

When operating on 20 meters, using an ordinary dipole (at the same height as the log periodics), reports from South and Central America average S8 to S9. When I switch to the log periodic the signal reports usually improve to 20 dB over S9. In most cases the S-meter in my receiver confirms this.

Although these reports seem to indicate gain greater than 10 dB, when compared to the dipole I use as a standard, some of the apparent gain is probably due to the lower radiation angle of the log periodic. Also, the theoretical gain of a log periodic is the result of line-of-sight tests on vhf and uhf antenna ranges, so they are not directly translatable to high-frequency performance.

If you check the specification sheets for commercial log-periodic antennas, you will find that the manufacturers rate their 12- and 13-element log periodics at 10 to 13.5 dB *over average soil conditions.* Front-to-back ratios are rated from 14 to 16 dB.

The lower radiation angle of the log periodic always results in higher performance than that predicted by theory, particularly on 20 meters. And, the longer the DX path, the greater the difference when compared with a dipole.

Operational tests on 15 and 10 meters have not been as outstanding as those on 20 meters, but most reports give at least a 10 dB advantage to the log periodic.

Reports off the back of the beam generally show a front-to-back ratio of at least 15 dB (also confirmed by my receiver S-meter). The front-to-back ratio is generally best on 20 meters, and slightly less on 15. The conditions on 10 meters have been too erratic to make good front-to-back signal-level comparisons.

One of the big operating advantages of the log periodic is the apparent diversity effect on receive. This is particularly noticeable during conditions of severe fading. Even signals coming in from the back of the antenna often have less fading when compared to a dipole. Evidently the large size (large capture area) of the log periodic provides this effect.

Since the log periodic is a broadband antenna it is well suited for operating on any frequency within the amateur bands it is designed for. The swr is low and nearly constant over the entire length of each band. Also, because of its broadband characteristics, there are no critical element or impedance-matching adjustments necessary after you put it up.

theory

According to log-periodic theory, the longest rear element must be at least 5% longer than one-half wavelength at the lowest desired operating frequency. For example, if the lowest operating frequency is 14.0 MHz ($\frac{1}{2}\lambda=33.4$ feet), the rear element must be not less than 35 feet long (33.4 feet + 5%). This element would resonate at about 13.3 MHz.

The shortest front element should be 45% to 50% shorter than one-half wavelength at the highest operating frequency. With 29.7 MHz as the upper frequency limit of the antenna, the front element should be resonant at 44.55 MHz minimum (29.7 MHz + 50%).

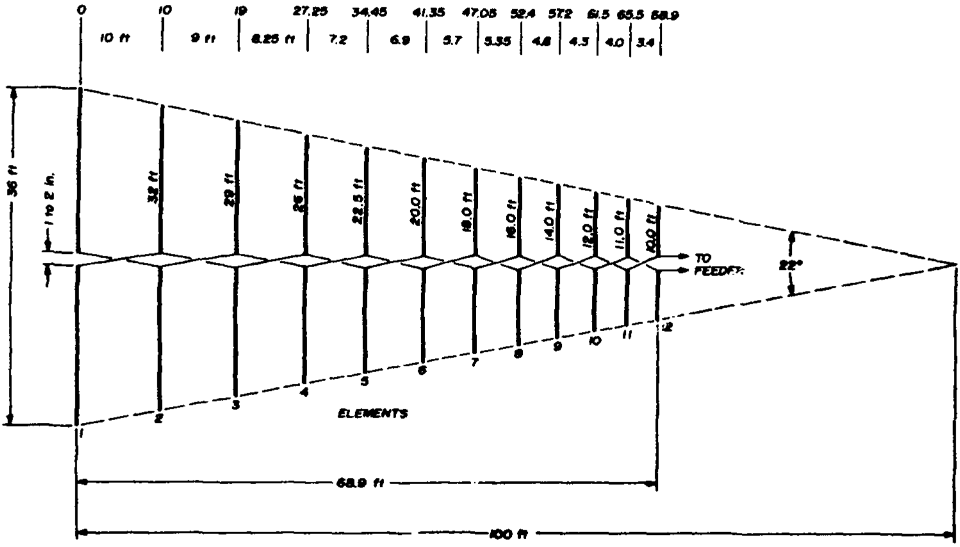

fig. 1. Three-band log-periodic antenna for 20, 15 and 10 meters provides approximately 10 dB forward gain.

For these reasons, a log periodic designed for 20, 15 and 10 meters should have a low-frequency cutoff of 12 to 13 MHz; high-frequency cutoff should be at least 45 MHz.

The log-periodic antennas shown in figs. 1 and 2, since they have the same number of elements, cost about the same, $35.00. However, this does not include support masts or feedline. This is not too bad for an antenna which provides 10 dB gain and performs equally well over each of the three amateur bands, 20 15 and 10.

If you don't have the space for one of these large antennas, you can reduce the size by eliminating one of the bands. For example, if 20-meter operation is not required, the three rearmost elements can be deleted. This leaves a 9-element log periodic that performs admirably on 15 and 10. The smaller, two-band antenna would only require a space about 25 feet wide by 35 feet long. You could even build a rotary log periodic for 15 and 10 meters on a 25-foot boom.

If 10-meter operation is not required, you can remove the three front elements, leaving 9 active elements for operation on 20 and 15. This reduces the length of the antenna by about 6½ feet.

construction

Since I use tall trees around my house to support the log periodics, weight must be kept to a minimum to gain maximum height. For the antenna elements, I use no. 15 aluminum electric fence wire which is available from Sears (catalog no. 13K22065). This wire is very inexpensive at $8.70 for ¼ mile of wire and is extremely light weight and easy to work. It has good strength and should also be suitable for rhombics and other long-wire antennas.

Connections to the aluminum wire are made by winding no. 16 or no. 18 tinned copper wire around the aluminum wire for about one inch. The junction is then covered with plastic electricians tape to keep out the rain and minimize electrolysis between the two dissimilar metals.

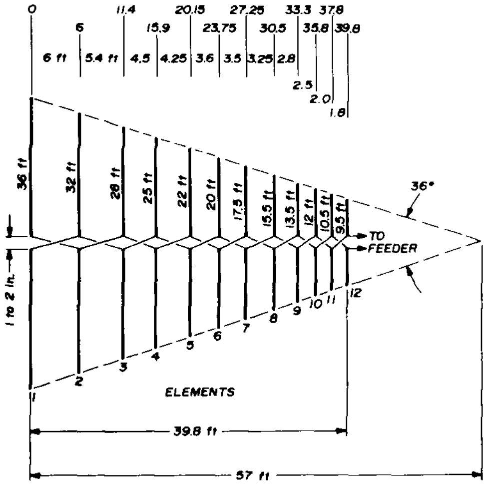

fig. 2. This three-band log periodic provides nearly the same performance as the design shown in fig. 1, but requires slightly less space.

All the center insulators used in my log periodic were made from Lucite or Plexiglass sheet, 1/8- to 1/4-inch thick. After cutting and drilling, the center insulators cost about 20 cents each. These insulators are also used as spacers and stringers for the open-wire feeder which runs down the center of the log periodic. For the three-band log-periodics shown in **fig. 1** and **2** you will need 12 center insulators.

The end insulators are made from monofilament fishing line (40 to 50 lb. test). At the rear element, however, if you use two rear masts, Isolantite antenna insulators should be used at the ends of the elements because the strain at this point is quite high, and may exceed the rating of the monofilament.

The monofilament apparently provides more than adequate insulation for 1000-watt transmitters. YV5DLT has advised that he has experienced no breakdown problems when using his SB-220 linear at full output. The monofilament I used is Sears Catalog number 6KV32232 (40 lb. test), which is priced at $1.88 for a 325-yard spool.

installation

The log periodic is suspended from the center with 3/16-inch nylon line (A in **fig. 4**) and two side catenary lines (C in **fig. 4**). The 3/16-inch, 800 pound test nylon line used for the A line carries most of the load and strain of the antenna, including the open-wire feeder and the center insulators.

Before installing the antenna, string the center nylon line through the ¼-inch hole at the top of each of the 12 center insulators. After the insulators are on the line, stretch the line between two posts about 60 or 110 feet apart (depending which log periodic you are building). The line should be at shoulder height so it's easy to work on.

The first center insulator will support the longest element as well as the rear end of the center feeder. A knot is tied in the A line just in front of the insulator to keep it from slipping forward on the line. Make sure the other 11 insulators are on the other side of the knot.

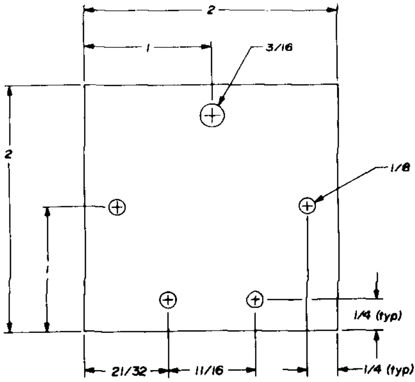

fig. 3. Insulators used in the construction of the log-periodic wire beams. Material is ¼" Lucite or Plexiglass.

Wrap several layers of masking tape around the nylon line to the rear of the first insulator. Leave a little space between the tape and the insulator so it hangs freely from the nylon line.

Now, using a steel tape, measure the spacing to the second insulator. Secure this insulator in place with several layers of tape around the line on each side of the insulator. Be sure to leave enough space between the tape layers so the insulator hangs freely on the center support line.

Continue along the center support line, measuring element spacing and installing center insulators, until all 12 insulators are correctly spaced and secured to the line. When spacing the insulators along the line it's a good idea to check the total spacing to make sure that no additive errors occur as spacing progresses. The total distance from the first insulator to the last should be 39.8 feet for the log periodic in **fig. 2**. For the larger antenna in **fig. 1** this distance is 68.9 feet.

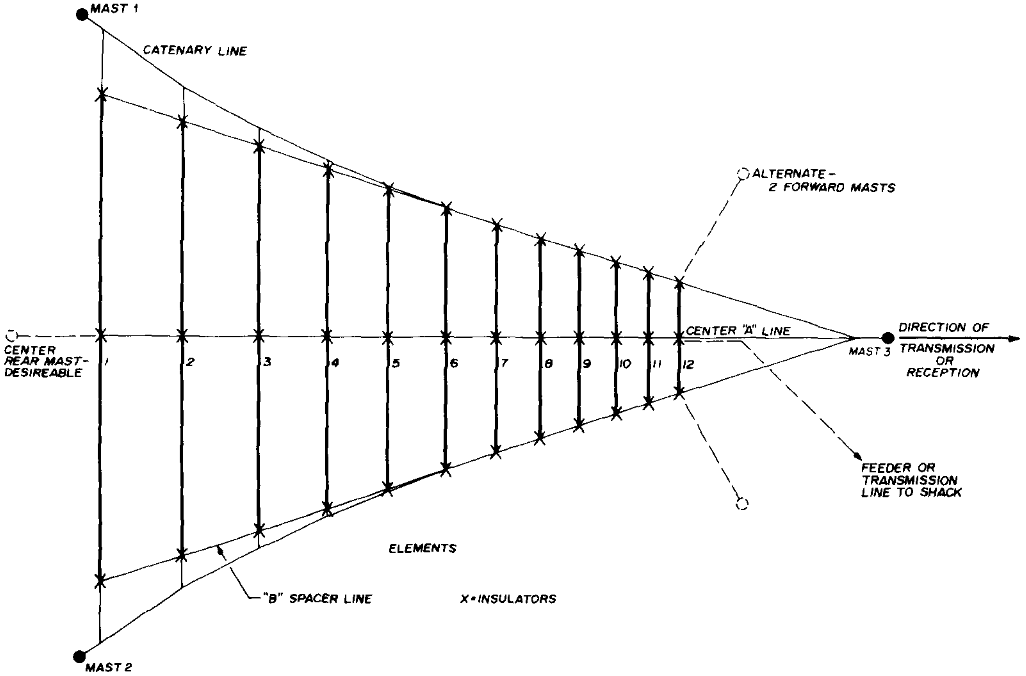

fig. 4. The log-period wire beams are supported by three nylon lines: the center A line and the two C catenary side lines.

I have found that masking tape will stand the weather better than friction tape or plastic tape, which often loosens up. The masking tape hardens and keeps the insulators in their correct position.

After the center insulators have been installed, assemble the parallel open-wire feeder by threading the two stranded wires (7/24 or equivalent) through the two number-2 holes in the center insulators. The parallel feeder wires are secured to the insulators with a few turns of no. 18 wire as shown in **fig. 5**.

The spacing of the center feeder does not appear to be critical. I have used spacings from 3/4 to 2 inches on different log periodics. Some of the commercial vhf-tv log periodics have center spacing up to 5 inches. No doubt this spacing could be used on high-frequency log periodic antennas, but the larger spacing would require more Lucite for the center insulators, and this would increase both cost and weight.

When the center feeder is in place, cut

the 12 elements from a length of aluminum electric-fence wire using the dimensions shown in the illustrations. Make the elements slightly longer, so there is several inches of wire for attaching the monofilament end inculators, and at least 8 inches for attaching the center insulators and connecting to the center feeder. Every other element is transposed as shown in **figs. 1** and **2.**

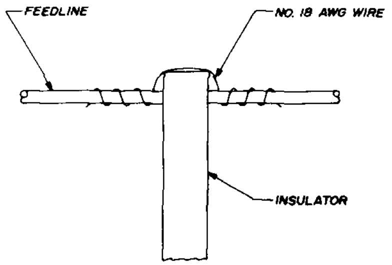

fig. 5. Lucite insulators are secured to the center feedline with a few twists of no. 18 wire.

Attach the 12 elements to the center insulators, starting at one end of the antenna and working toward the other. Leave the ends at the center disconnected for the time being. After all the elements are attached to the center insulators, install the monofilament end insulators.

The two B lines are simply longitudinal spacers to keep the elements parallel during assembly and at right angles to the center feeder. These lines can be 1/8-inch or smaller since they carry no load (number 18 nylon twine, 165 lb. test, is satisfactory, and inexpensive at $1.85 for a 500-foot spool).

Next, the elements are attached to the two C bridles or catenary lines which take most of the side load. For the C lines, 1/8-inch nylon (375 to 500 lb. test) is suggested. This can be purchased at marine or hardware stores for about 3 cents per foot.

The center A line and the two C catenaries should be stretched tight, about 6 feet off the ground. When the catenaries are stretched into place they will appear as a large V, with the apex aimed in the desired operating direction. The A line should pass through the center of the V, bisecting it equilaterally.

By suspending the complete antenna between the same supports that will be used in the final installation, but at six feet above the ground, it is easy to adjust the tension of the elements from the ground.

The distance from the shortest element to the apex of the V should be 17.2 feet (**fig. 1**) or 31.1 feet (**fig. 2**). Less than this will allow the front element to sag too much.

Attach each of the elements to the catenaries with nylon twine, working from the shortest element to the longest. Use temporary knots, because it may be necessary to adjust the tension after all the elements are installed. Note that the six front elements usually fill the space between the B and C lines where the B line is adjacent to the C line.

Starting at element number 7, the C lines will require more and more separation to provide sufficient tension on the longer rear elements.

At this point it may be necessary to adjust the spacing between the end insulators and the C lines so there is as little element sag as possible, but don't put too much strain on the nylon support lines. There will also be some fore and aft sag of the center A line due to the weight of the feeder, insulators and wire elements, but the antenna should now be starting to take shape.

center feed

The center feedline to each of the elements of the log periodic must be transposed as shown in **figs. 1** and **2.** I have tried two methods of doing this. On the antennas shown here each feeder is transposed 180° between each of the elements. This is the system usually used in the schematic representations of the log periodic.

With this method of feeding power to the elements, insulated wire must be used for the feeder. With high power, you might have problems with insulation breakdown. Bare wire can be used for the feeders, but insulated transposition blocks are required between elements, adding both weight and cost.

The second center feed method uses *an open wire parallel* feeder with criss-crossing wires to each of the elements as shown in **fig. 6.** This feed system is easier to build, and presents a neater appearance.

feedline

Most of the rotatable vhf and uhf log-periodic antennas proviously described in the amateur radio magazines have used 50- or 72-ohm coaxial feedlines.[4,5,6] However, a coaxial feedline is not suitable for the high-frequency log periodics described here because the cable is much too heavy. For these antennas, a light-weight feeder is required.

Normally, the log periodic is fed from the front (short-element) end. The input impedance at this point is about 30 to 35 ohms, as measured with an Omega Antenna Noise Bridge.* I checked several different log-periodics with the Noise Bridge, and all fell into the 30- to 35-ohm range.

However, if the open center feed is extended to the apex, the input impedance increases to approximately 100 to 300 ohms.[8] The open center feed operates as an impedance transformer, and at a point that is an odd number of wavelengths from the active elements on 20, 15 and 10 (20 meters, element 2; 15 meters, element 5; 10 meters, element 8) the input impedance remains fairly constant over each of the amateur bands. This point is within several feet of the apex.

Since the input impedance of the antenna depends upon feed point location, several possible transmission lines may be used. Since the input impedance at the front element is quite low, one of the best methods of feeding the antenna is with tuned open-wire feeders, with an antenna tuning unit between the coaxial output of the transmitter and the open-wire feed-line.

Although a coaxial feedline adds a great deal of weight to the antenna, and results in a sagging log periodic, it can be connected directly, through a balun, to the front-element feed point. Tests here, with RG-8/U coaxial cable, indicate a fairly good match on 20, 15 and 10. The standing-wave ratio on the 14-MHz band ranges from 1.1:1 to 1.3:1 from one end of the band to the other. On 21-MHz, the swr varies from 1.3:1 to 1.7:1, and on 28 MHz, the swr is from 2.0:1 up to 2.5:1.

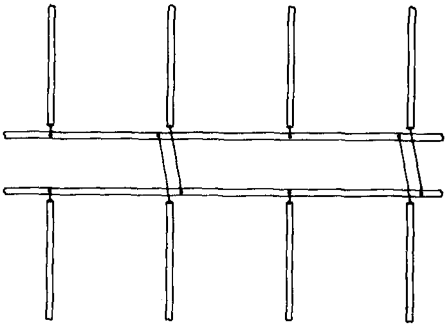

fig. 6. The required feedline transposition is most easily accomplished with criss-crossing wires to each of the antenna elements.

The swr on 10 meters is somewhat higher than that on the two lower bands, but it is still within tolerable limits, and on-the-air tests on 10 meters indicate very good performance.

At my station neither the tuned open-wire feeder nor the coaxial cable were suitable for a permanent installation. Since I use trees to support the antenna, the weight of the coax cable caused the antenna to sag too much, and valuable height was lost. Also, several of these antennas are several hundred feet from the station, so the cost of coaxial feedline is prohibitive.

The long length of the feedline makes open-wire feeder impractical because of the large number of spacers to be in-

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*When using the Antenna Noise Bridge, the *frequency* dip normally exhibited by a sharply tuned antenna is completely absent with a log periodic because of its broad-band operation.

stalled, and the amount of work required to install the transmission line.

For these reasons I tried 72- and 300-ohm tv twin-lead. I tried the 72-ohm twin-lead first, connecting it to the transmitter through a short section of coaxial cable. For minimum swr (at the transmitter) I had to prune the length of the 72-ohm feeder – by removing short lengths (about 1/8-wave at 28 MHz), and making swr measurements, I arrived at a feeder length which provided fairly low swr on each of the three bands. A 1:1 balun between the twin-lead and the coax input didn't appear to make any difference.

When I tried out the 300-ohm twin-lead, connected near the apex, I used a 4:1 balun transformer between the twin-lead and the coax to my transmitter. This system worked quite well, and provided good performance on all bands. Although tv-type twin-lead will not handle a kilowatt, it is adequate for the 250 watts which I use. For higher power installations, transmitting-type 300-ohm twin-lead is available.

With the 300-ohm twin-lead feedline, the swr on 14.0 MHz was measured at 1.7:1, dropping to 1.5:1 at 14.2 MHz and 1.3:1 at 14.35 MHz. On 21.0 MHz the swr was 2.2:1, increasing to 2.5:1 at both 21.2 and 21.45 MHz. On ten meters, the swr was 2.2:1 at 28.0 MHz, dropping to 1.9:1 at 28.5 MHz, increasing to 2.1:1 at 29.0 MHz, and dropping again to 1.9:1 at 29.5 MHz. When plotted on a graph, these swr figures result in pretty flat performance over each of the three amateur bands.

summary

Since the forward lobe of the log periodic is generally broader than that of a Yagi, it is quite suitable as a fixed, non-rotatable, gain antenna. When my antenna farm is completed, I will be able to cover the United States and several continents with six three-band log-periodic antennas. Six dpdt relays will be used to connect the desired 300-ohm feeder to a 4:1 balun which is connected to the coaxial transmission line to the transmitter.

These light-weight log periodics have been very durable. One has been up for a year, with absolutely no trouble. Three were up last winter and withstood two bad ice storms; they sagged a bit with the ice load, but as soon as the ice melted, they returned to their normal height. They have also withstood a couple of twisters which passed a block away, snapping a number of tall pines.

If you like to build and test antennas, or are looking for DX and consistent contacts in a certain direction, I highly recommend the light-weight log periodics described here. At the present time I am working on two side-by-side log periodics pointing in the same direction. This should increase the gain by about 3 dB, to 13 dB for the two-antenna system.

I want to thank all those who have been helpful in giving reports and running tests on the log periodics, especially the Central and South American operators, for their patience and accurate reports. Special thanks goes to YV5DLT in Caracas for the many tests over the past year, and the nearly daily schedules during the design and testing of these antennas.

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