ham radio TECHNIQUES

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As of this writing (mid-June) it looks as if the FCC is slowly moving toward the possible release of additional frequencies for Amateur Radio, as authorized by the 1979 World Administrative Radio Conference. A good guess is that the so-called 24-MHz band may be released on Special Temporary Authority in the near future.

Interest in the new bands has received a boost because of the ARRL Antenna Design Competition, announced this past spring.[1] The goal of the contest is to provide new antenna designs that can be constructed at home and will cover as many of the WARC-79 bands as possible. The two entry categories include a five-band design that will cover all Amateur bands between 14 and 30 MHz and a six-band design that adds the 10-MHz band. (Details are listed in **table 1**; a "design frequency" indicating the midpoint of each band is also listed.)

table 1. Most antennas built for the design frequency specified will work well over the whole Amateur band. Two design frequencies are chosen for 10 meters, one for operation at the low frequency end of the band and one for operation at the high frequency end.

band (MHz)	design frequency (MHz)
10.100-10.150	10.12
14.000-14.350	14.17
18.068-18.168	18.11
21.000-21.450	21.22
24.890-24.990	24.94
28.000-29.700	28.60 (low)
	29.20 (high)

the "multiband" antenna

The problem of designing a single antenna that covers the frequency range of 14 to 30 MHz (or 10 to 30 MHz, as the case may be) is an interesting one. No doubt many fascinating antenna designs will surface during the next few months. One basic choice that must be made is whether the antenna designed will be a wideband type that covers the entire frequency span, or a type that functions only over the bands in question. Let's look at the wideband concept first.

For this discussion, a wideband antenna is defined as one that has relatively constant gain, polarization, and

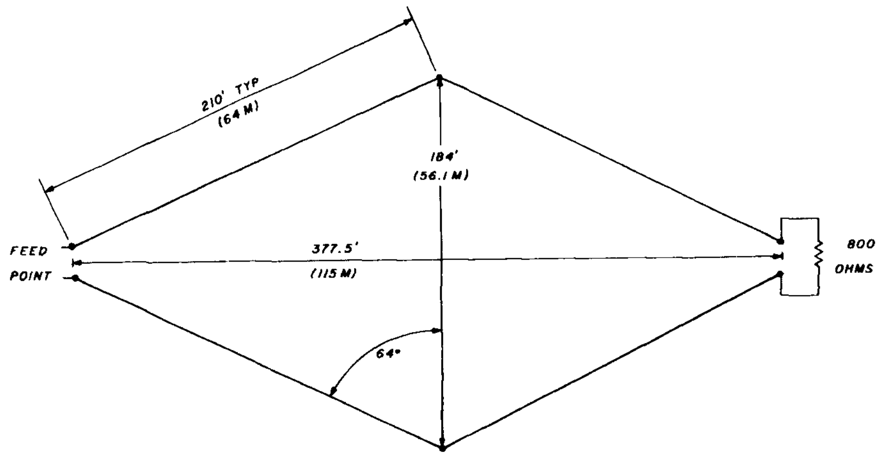

fig. 1. A terminated rhombic antenna for the frequency range of 14 to 30 MHz. Antenna is terminated with a noninductive resistor capable of dissipating about half the transmitter average power output. (Design taken from *The ARRL Antenna Book*, 14th Edition, Chapter 7, fig. 16.)

mpedance characteristics over the ɔperating range.

One of the earliest wideband gain ɜntennas is the terminated rhombic[2] ;hown in **fig. 1**. This antenna works ᴎell over a 2-to-1 frequency range, ɔrovides good front-to-back ratio and ;an exhibit as high as 14 dB gain over ɜ dipole, providing the leg-length of :he array is long enough. The front-to-ɔack ratio is achieved by choice of leg ength and the use of a terminating re-;istor, at the far end of the array, ᴎhich absorbs reflected power. Be-;ause the feedpoint resistance is about '50 to 800 ohms, an impedance match-ng transformer is required to match he antenna illustrated in **fig. 1** to a ;0-ohm transmission line.

Other varieties of traveling-wave an-ennas, such as the terminated V-an-enna, exist, but their main disadvan-age is their large size and the corre-;ponding amount of real estate they equire.

:he log-periodic array

Two relatively new types of wide-ıand antennas, the equiangular anten-ıa and the log-periodic antenna, are nore practical for Amateur service.

The equiangular antenna evolved 'om the observation that the proper-es of an antenna (impedance and pat-ɜrn) are determined by its shape and imensions with respect to operating ᴎavelength. When the antenna is caled, its properties are independent f frequency, provided its form is spec-ied only by angles and not by any par-cular dimension. A two-arm equian-ular spiral antenna, shown in **fig. 2**, ; an example of this design.

This antenna is a variation of the di-ole, where the two halves have been ᴎisted into a pair of equiangular arms. he antenna is fed by a balanced line t the center point. High frequency utoff is determined by antenna con-guration near the feedpoint; low fre-uency cutoff is determined by the uter circumference of the spiral, in-icated by the dashed line. Feedpoint ;sistance of the antenna is quite high, ɘing of the order of 120 to 180 ohms, ɘpending upon antenna size and de-

fig. 2. The two-arm equiangular dipole antenna is fed with a balanced line at F-F. The feedpoint impedance is relatively independent of frequency over operating range. Low frequency operating limit is defined by the circumference of antenna, indicated by the dashed line. (Drawing adapted from Jasik[2].)

sign. Frequency spans as great as 10-to-1 have been achieved in practice with this antenna type.

A second wideband antenna design, with which most Amateurs are familiar, is the log-periodic antenna (**fig. 3**).* The geometry of this antenna design is chosen so that the electrical properties repeat periodically with the logarithm of frequency. The basic trapezoidal-tooth log periodic structure is shown in the illustration.

The design can be further simplified if the structure is replaced by dipole elements (**fig. 4**). This log-periodic dipole antenna is a popular design for TV and FM receiving antennas, and versions of this antenna are often used by Amateurs on the VHF bands. The frequency limits of this antenna are those at which the outer elements are about one-half wavelength long.

The dipoles are fed at the center from a parallel wire transmission line in such fashion that successive dipoles have 180-degree phase reversal between them. A broadband structure is formed, with most of the radiation coming from the section containing elements approximately half a wavelength long at the operating frequency. Gain and bandwidth bear a definite relationship to the length and included angle of the antenna.

Unfortunately, at any given frequency in the operating passband, some of the elements in this array are inactive; the active element area moves along the structure as the frequency of operation is changed. At the lowest operating frequency, the longest elements have the most current in them and, as operating frequency is raised, the center elements become active and have the greatest current in them. At the upper frequency of operation, the shortest elements have the greatest current in them, with the longer elements relatively inactive. Thus a log-periodic dipole beam antenna must be considerably longer than a parasitic Yagi antenna of equivalent gain.

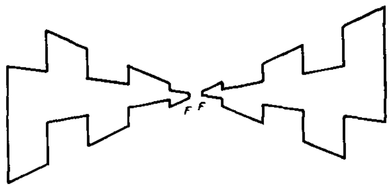

fig. 3. The geometry of the planar, log-periodic dipole antenna repeats periodically with the logarithm of the frequency.

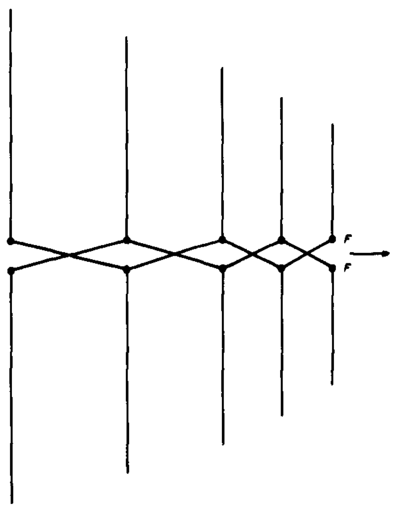

fig. 4. The log-periodic dipole array, in which linear elements replace the "teeth" of the antenna shown in *fig. 3*. This structure forms a beam antenna.

*Designed by KLM Electronics, Morgan Hill, California 95037.

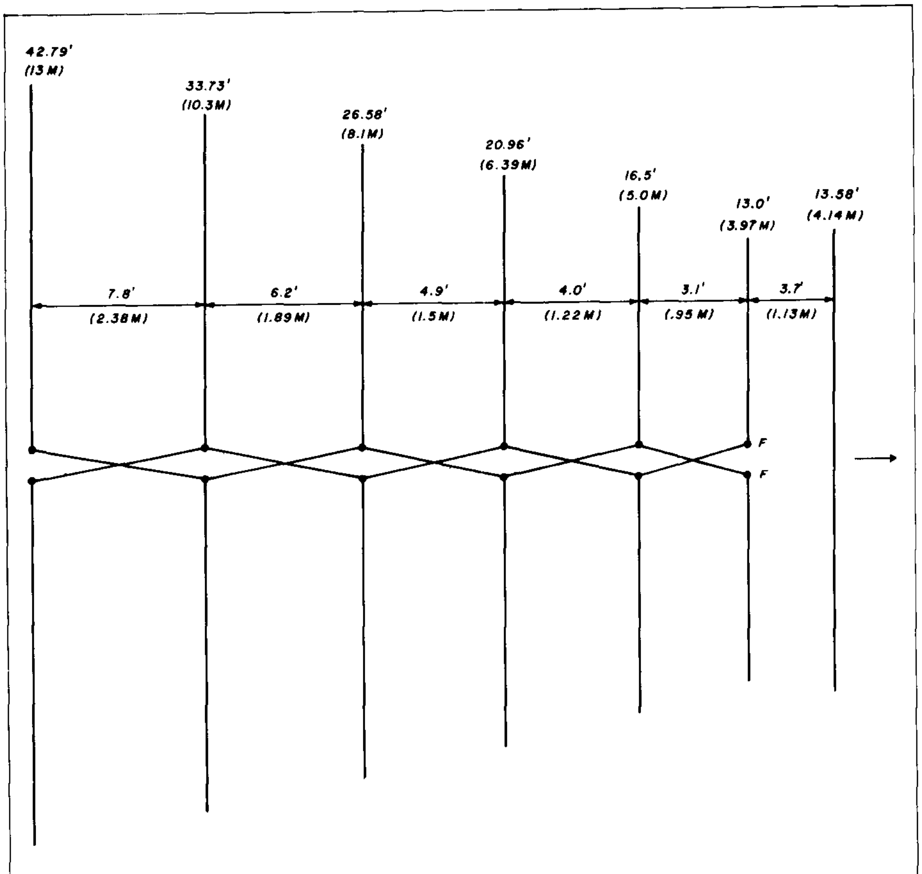

fig. 5. the KLM 13-30 LPY array covers 13-30 MHz with an average power gain of 5 dB over a dipole. The average front-to-back ratio is 15 dB. The array uses a single parasitic element.

the log-periodic Yagi

An interesting version of the log-periodic design is the log-periodic Yagi (LPY) antenna (**fig. 5**). This passband array provides higher gain per unit of length than the original designs, making use of a log-periodic dipole structure having the frequency characteristics of a bandpass filter. One or more parasitic elements are used to boost the gain of the log-periodic structure. Trimming the parasitics to specific frequencies can enhance the gain of the array at these frequencies at the expense of gain loss at other frequencies. Thus, an LPY antenna can be designed for maximum performance in closely adjacent Amateur bands (14, 18, 21, and 24 MHz, for example).

Other interesting wideband antennas exist but are not practical for use in the HF spectrum because of their size.

narrowband tuned antennas

The easiest way to get on one of the proposed new HF Amateur bands is to use a dipole cut to the midpoint of the band. A more useful antenna is a half-wave wire cut to the lowest band (for example, 10 MHz) and fed at the center with an open wire transmission line and an antenna tuner (**fig. 6**).

This is a very simple antenna and, when properly built and tuned, will cover all Amateur bands between 10 and 29.7 MHz. In fact, if the tuner is flexible enough, this antenna can also be used for the 40 and 80-meter bands, thus making a true "all-band" HF antenna.

At my station, I have an old Johnson Kilowatt "Matchbox" tuner that I picked up at a flea market. No longer made, this useful device will match almost anything at any frequency in the HF region. With this, or an equivalent tuner, the center-fed antenna dimen sions are not critical at all because th tuner makes up for variation in anten na and feeder length. If difficulty i experienced in loading up a particula combination of flat-top/feede lengths, adding or subtracting a foo or two of feeder length will usuall cure the problem.

parallel-connected dipoles

A simple multiband antenna used i the HF region consists of two or mor dipoles connected in parallel at th feedpoint. The ends of the dipoles ar separated a foot or two. This arrange ment works well when the bands ar harmonically related (7, 14, and 2 MHz, for example), but problems aris when the principle is applied to th new HF bands. Dipoles for 18 and 2 MHz, for example, when paralleled i this fashion do not seem to perfor properly. The 18-MHz dipole is una fected, but the 24-MHz dipole is con pletely detuned and will not perform all! Other combinations have not bee tried, to my knowledge, but perhap one of *ham radio*'s readers will try di ferent combinations, such as 10 and MHz, or 14 and 24 MHz. I think th parallel-dipole approach has merit, b I haven't hit upon the lucky combin tion that works for the new bands

the multiband loop antenn

One interesting antenna that w cover five or six bands when used wi an open wire line and tuner is th quarter-wave loop antenna (**fig. 7** With each side cut to 24 feet 6 inch (7.47 meters), the loop will cover bands from 10 MHz up through meters. Most loops of this type a mounted in the vertical plane and f at the bottom to provide horizontal p larization. Some experimenters ha had luck with this loop mounted in t horizontal plane, about 30 to 40 fe above the ground. Horizontal polariz tion is still provided.

If operation is desired only on MHz and up, the sides of the loop c be reduced to 13 feet 9 inches (4 meters).

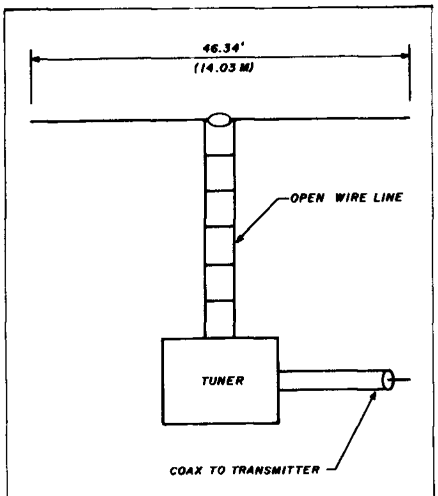

fig. 6. The 10 MHz dipole fed with random-length open wire line provides operation on all bands between 10 and 30 MHz if proper tuning unit is used.

the trap dipole

The trap dipole (**fig. 8**) makes use of the high impedance of a parallel resonant circuit to isolate or decouple unwanted tip portions of the antenna. The inner set of traps is placed in the element to isolate the center portion for operation on the highest frequency band (f_1). A second set of traps may be placed somewhat farther out along the element to isolate a longer portion, with the first set of traps becoming part of the antenna element at the lower operating frequency (f_2). Trap dipole antennas have been built with eight traps to allow operation on four Amateur bands. Trap design is straightforward, but determining the length of the tip sections, and the wire length between the traps is usually done on a cut-and-try basis.*

An approximate system for mathematically determining the length of the tip sections has been described in the Amateur literature.[3]

trap construction

Traps can be built either with discrete components (inductors and capacitors) or by using a length of coaxial line as a combined inductor and capacitor. Gary O'Neil, N3GO, described an interesting coaxial cable trap in *ham radio*, just a few years ago.[4] While his design provided somewhat better operational bandwidth than the conventional trap design, unfortunately, any form of trap made of coaxial cable is very difficult to accurately adjust to frequency because any variation in the spacing of the coiled cable can change the resonant frequency of the trap many hundreds of kilohertz. Trap construction and adjustment become quite a problem.

*An article on a computer-aided design for a trap antenna is scheduled for publication in October. — Editor

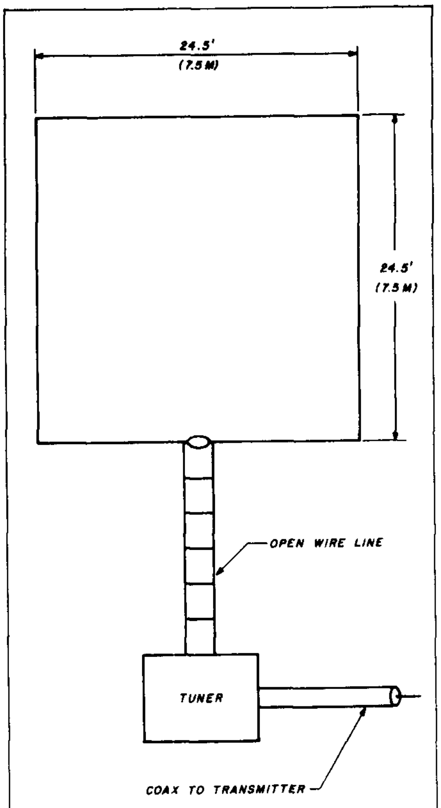

fig. 7. A simple quad-type loop antenna that will cover all bands from 30 through 6 meters. Open-wire line and antenna tuner provide balanced feed from a coaxial system.

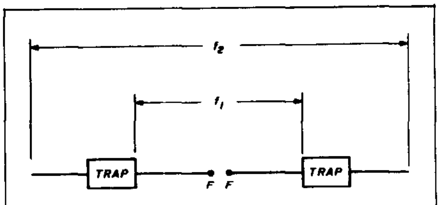

fig. 8. Trap dipole employs electrical "switches" to connect and disconnect antenna tips automatically for operation at frequencies f1 and f2.

The trap made up of a capacitor and a separate inductor is easier to adjust to frequency, which is usually chosen as the midpoint of the band. A fixed, high voltage capacitor is commonly used; one popular unit is a 25 pF, 5 kV ceramic type.* Frequency can be adjusted by pruning the parallel-connected coil. Many Amateurs use prewound, spaced air inductors mounted on four plastic strips. One type of coil, the "miniductor" manufactured by Barker & Williamson Co., is suitable for this purpose.†

Unfortunately a trap made up of an air coil and a ceramic capacitor must be protected from the weather. Water can damage the capacitor, and ultraviolet light from the sun can quickly ruin the plastic strips supporting the coil! Solving these problems is not an easy task, and any ideas supplied by the readers as to the design of a weatherproof trap assembly would be appreciated.

practical two-band dipole for 18 and 24 MHz

Here's a simple antenna you can build in anticipation of the happy day when the 18 and 24-MHz bands are made available to Radio Amateurs for general communication. Important antenna dimensions are shown in **fig. 9**. The traps are made of a coil-capacitor combination, as discussed previously, and mounted to a small ceramic insulator which serves to take the pull of the antenna.

Before the traps are installed, they must be frequency-checked with a dip oscillator and a calibrated receiver. Place the trap in an area free of nearby metallic objects and loosely couple the dip oscillator to it. When reso-

*The popular Centralab type 850 capacitors are no longer made by this company. I understand an equivalent type is manufactured by Jennings Radio Co., 970 McLaughlin Avenue, San Jose, California 95122, and also by High Energy Corp., Lower Valley Road, Parkesburgh, Pennsylvania 19365.

†Barker & Williamson Co., 10 Canal Street, Bristol, Pennsylvania 19007

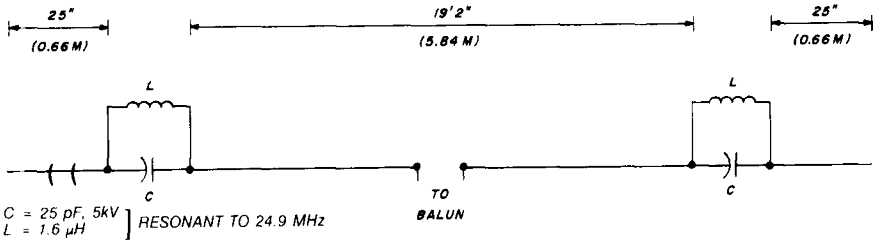

fig. 9. Trap dipole antenna for the 18 and 24 MHz bands. The trap is held in position by a 4-inch long ceramic insulator. The antenna is fed from a 1-to-1 balun and 50-ohm coaxial line.

nance is indicated, note the frequency of the oscillator on the nearby receiver. The traps should show resonance within ±100 kHz of 24.9 MHz. One end turn on each trap should be broken free of the coil bars so that it can be moved about to set the exact resonant point of the trap. You'll find that when you attach the trap across the supporting insulator, the resonant frequency will drop a bit because of the capacitance across the insulator. It's best to shoot for a resonant trap frequency about 24.9 MHz; the insulator capacitance will then place your trap "right on the nose." You can also run your checks after assembly — take your choice.

The length of the other tip sections is critical for proper operation on 18 MHz. Varying the tip length by as little as one inch per end will change the resonant frequency about 150 kHz. Since the band is only 100 kHz wide, this means tip dimensions are critical to about an inch to establish antenna resonance within the band.

The tip dimensions shown in **fig. 1** are quite accurate. If you want to frequency-check the whole antenna, suspend it in the air, in the clear, about six feet above the ground. Place a 1/2-turn inductor across the center insulator, and measure the 18 and 24 MHz frequencies of the complete antenna with a dip oscillator coupled to the inductor.

When I made my antenna I cut the tip sections about a foot longer than necessary and then folded them back and twisted the wires around the active antenna wire. That provided plenty of extra wire in case I had to lengthen the tip sections. Once I reached the correct length, I cut off the excess wire.

After some minor adjustments were made I found out that removing one inch at each end of the center dipole raised the resonant frequency of the antenna 100 kHz/inch at 24.9 MHz. (Since the length of the 24.9 MHz dipole affects the resonant frequency of the 18.1 MHz dipole, pruning the 24.9 MHz dipole must be done before the tip sections are adjusted.)

When the antenna was completely tuned, it was hauled up my tower and anchored at the 45-foot level, with the ends dropping down to the 25-foot level and tied to two nearby trees. SWR measurements revealed that the maximum figure on either range was under 1.3-to-1, with near-unity SWR at the design frequency on each band.

Note: More information on multiband antennas and trap antennas can be found in the 22nd edition of ***Radio Handbook****, available from Ham Radio's Bookstore, Greenville, NH 03048, at $21.95, postpaid.*

references

1. "Announcing the ARRL Antenna Design Competition," *QST*, March, 1984, page 56.
2. E. Bruce, A.C. Beck, and L.R. Lowry, "Horizontal Rhombic Antennas," *Proceedings of the IRE*, Volume 23, January, 1935, page 24. Also, H. Jasik, "Antenna Engineering Handbook," McGraw Hill Book Co., New York, page 4-12 to 4-33.
3. "Trap Dipoles," *ARRL Antenna Handbook*, 14th Edition, 1982, American Radio Relay League, Newington, Connecticut, Chapters 8-4 and 10-5.
4. Gary E. O'Neil, N3GO, "Trapping the Mysteries of Trapped Antennas," *ham radio*, October, 1981, page 10.

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