compact dual-band antennas

Simple but effective antenna systems for city-lot dimensions or portable use

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It's hard to "be loud" when your antenna is on a city lot. Power lines and apartment buildings make it almost impossible to put up a full-sized antenna. It is possible, however, to reduce the length of a dipole by one-half using the folding technique. A shorter dipole combined with a folded dipole is an efficient two-band antenna system that can be erected in a restricted space. Such an arrangement is also useful for portable or Field Day work. Versions of this system are discussed in this article.

basic concepts

Two dipoles may be connected in parallel at a current loop as shown in **fig. 1**, provided an even-harmonic relationship exists between them. End separation of both antennas need be only a few inches. Although a small amount of detuning will exist, the usual formulas for dipole length apply.

Various combinations are practical for two-band systems: 160/80, 80/40, 40/20, 20/10, and so on. The 40/20-meter combination will work on 15 meters if the 40-meter antenna is operated on its third harmonic. An 80/20 or 80/10-meter system can be built (using the even-harmonic rule) with a reasonably low standing wave ratio on the transmission line. As with any system using an unbalanced transmission line feeding a balanced antenna, a balun should be used to preserve antenna pattern and to avoid feed problems.[1]

folded half-wave radiator

The length of this simple dual-band system can be reduced by folding the lower-frequency antenna back on itself. A three-wire antenna is shown in **fig. 2.** The feed point is connected to one of the outside pairs of wires and also to the inner pair. The two outside wires are jumpered at their far ends; they are the elements of the low-frequency dipole.

Folding the antenna has a minimum effect on its resonant frequency. If you'd like to refine the resonant frequency adjustment, compensation may be made in the manner shown in **fig. 3.** The low-frequency dipole should be trimmed for the low-frequency end of the band. The resonant frequency can then be raised by moving an adjustable jumper across the wires at the end. If the jumpers are adjusted in unison, resonant frequency may be varied over several-hundred kHz.

The higher-frequency dipole (center wire) will be unaffected by this adjustment. It may be adjusted by changing its length until resonance is achieved.

system bandwidth

The bandwidth of any antenna may be defined in terms of the allowable standing wave ratio on its transmission line. Beam antennas with close-spaced parasitic elements have very low radiation resistance and limited bandwidth. If they are operated at an swr much higher than 2:1, forward field and front-to-back ratio will deteriorate rapidly at frequencies only a few percent from resonance. Simple dipoles, on the other hand, can operate over a much wider frequency range. This is because there's no problem involving phase and reactance relationships between elements as with parasitic beams.

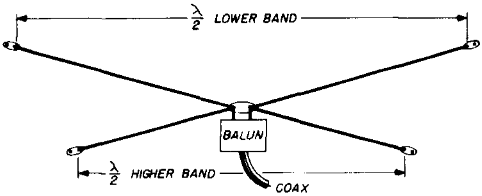

fig. 1. Basic dual-band antenna. Dipoles are parallel-connected; an even-harmonic relationship must exist between them.

Equipment limitation is probably the most important factor that affects allowable transmission-line swr. Many commercial amateur transmitters and transceivers have limitations of 2:1 for standing wave ratio to avoid ruining output-circuit components (usually a pi network). It is therefore prudent to operate such equipment into antenna transmission lines with an swr of 2:1 or less. Let's see how the dual-band radiator measures up to this criterion.

height above ground

Taking an swr of 2:1 as par, the plot of **fig. 4** shows the swr of the dual-band dipole when operated at optimum height above ground. The data for these curves was taken at the end of a 100-foot length of 50-ohm coaxial cable.

The 40-meter dipole has greater bandwidth: more than 400 kHz, with an swr of 2:1 or less. The 80-meter folded dipole's bandwidth is about 75 kHz over the same swr range. This indicates that the 80-meter antenna height is more important, in terms of swr, than that of the 40-meter antenna. I raised and lowered my 40-meter antenna and observed its swr across the band. It performed satisfactorily at heights above 20 feet or so, with a rather small change in swr. The swr reached a broad optimum at a height of 30 feet and again at 60 feet. Highest swr was at about 45 feet.

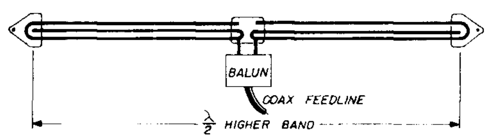

fig. 2. Dual-band system using the folding technique. Center wire is the higher-frequency dipole; the two outer wires comprise the lower-frequency dipole. Interaction is negligible.

The 80-meter antenna is a different breed of cat. Because of folding, the 80-meter dipole's radiation resistance is lower. It's about 60 percent of the usual measured value at all heights above ground. The 80-meter antenna plot of **fig. 4** occurred at about 50 feet and remained reasonably constant down to 40 feet. Below this height, minimum swr increased rapidly, tending to decrease the over-all bandwidth.

Accepting these facts of life, I finally mounted the antenna so that the flat top was about 45 feet high. The 40-meter-band swr wasn't as good as shown in **fig. 4**; however, it remained below 2:1 from

7.1 to 7.3 MHz It was still acceptable at 7.0 MHz, as no equipment-loading problems were encountered at this frequency. The 80-meter swr values were as shown in **fig. 4.**

feed system

The transmission line must be decoupled from the antenna to obtain lowest swr. Decoupling will keep the line from radiating. A sure way to create transmission-line problems is to attach an unbalanced coaxial line to a balanced antenna. The reason is that current flows down the outside of the line instead of being confined to the inner conductor. A balun placed at the dipole feed point will decouple the line's outer shield from antenna currents. The balun is shown in **fig. 5.** It's mounted directly at the center antenna insulator.

balun construction

The balun consists of three trifilar windings of no. 14 enamelled copper

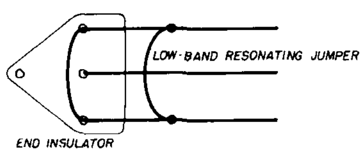

fig. 3. End insulator and resonating jumper. Each side of the assembly should be of equal length; jumpers should be moved in unison.

wire. Each winding consists of 8 turns. The coils are wound over a length of high-Q ferrite rod, ½-inch in diameter.* Nick the rod with a file around its circumference at the desired length, then break it with a sharp blow. Connect the ends of the windings as shown in **fig. 5.**

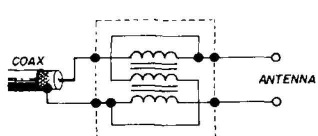

fig. 5. Balun for optimum performance. Inductances are wound over ferrite cores; see text.

Note that the coax shield is connected to the outer winding and also to the opposite end of the center balanced winding.

transmitter loading

The RG-8/U feed line (or RG-58/U if power is below 250 watts PEP) should drop vertically as far as possible. The line then may be run horizontally when near ground level. Since a relatively high swr exists, it may be necessary to vary line

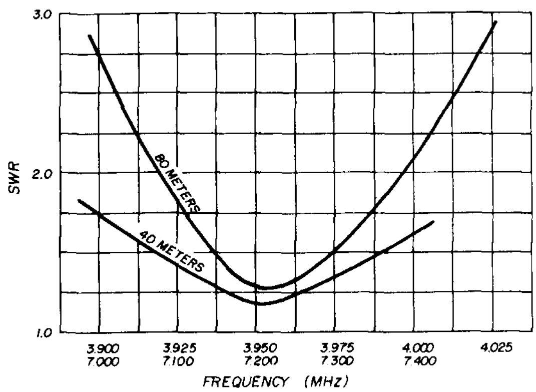

fig. 4. Standing wave ratio versus frequency for the compact dual-band dipole. Curves were optimized for antenna height.

length to obtain optimum transmitter loading. This doesn't change the swr; it merely provides conditions for a better impedance match at the transmitter end of the line. Make a couple of ten-foot lengths of line with appropriate connectors. Try inserting one or both sections into the main transmission line until the transmitter loads properly. If loading difficulty still persists, a longer line section may be necessary to obtain proper loading on both bands. Line length isn't nearly as critical as it may seem — I mention it only because loading difficulties might develop.

dual-dipole construction

Construction is simple. The end and

*Indiana General CF-503 rod, available from Newark Electronics. Catalog part no. 59F-1521.

center insulators may be made of 3/8-inch plywood squares about six inches long. For outdoor use the insulators should be treated with spar varnish to make them waterproof.* Holes for the antenna wires should be about two inches apart. String the wires, then stretch the system between two supports about waist high. You'll notice that separators will be needed between the wires, spaced at about 5-foot intervals. You can make these from short pieces of plastic rod.

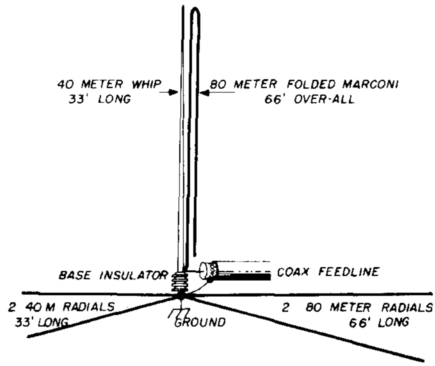

fig. 6. Compact dual-band Marconi antenna. Ground system is important; a ground rod was used in addition to the radials, which can be oriented at random.

Drill the separators to accept the wire, then thread the separators onto the wires. Secure the separators with small-diameter wire ties.

The first antenna of this type that I built had untreated insulators and separators. They lasted about a year, then succumbed to a combination of weather and birds. This construction isn't recommended except for temporary installations.

Commercial versions of this compact antenna system are available. When used with a balun, performance will be as described here. Again, I'd like to emphasize that this antenna, when operated without a balun, will lead to unusual or puzzling operating conditions. Play it safe and do the job right.

Typical antenna dimensions are given in **table 1**.

dual-bank Marconi antenna

The parallel-feed system may be adapted to Marconi antennas as well as to dipoles. With a Marconi, a ground system is required for proper operation **(fig. 6)**. The random "water-pipe" ground is not recommended. Two or three radials should be used at the ground connection in a Marconi antenna installation. Two ¼-wavelength radials for each band will be adequate. The radials may be of insulated wire; they don't necessarily have to form the spokes of a wheel from the ground connection. They can be fastened to fences or any handy anchoring device.

The Marconi is usually in the form of a base-supported whip. The easiest way to erect a Marconi antenna for two-band operation is to use a ¼-wave whip made of tubular material for the higher-frequency band, which acts as a support for a folded-wire section cut for the lower-frequency band. Insulators such as those used for tv lead-in may be installed on the whip to support the folded-wire antenna The folded-wire antenna will require insulated spreaders, as discussed previously.

Radiation resistance of the whip antenna is lower than that of the dipole system. However, height above ground has less effect on the whip's bandwidth. A typical 80/40-meter Marconi, for example, has an swr of 2:1 or less across the 40-meter band. An 80-meter system has a bandwidth of about 80kHz.

An added benefit of the vertical Marconi is a low radiation angle, which is good for DX work. Best results will be obtained only if a good radial system is used.

*Another time-honored method of waterproofing wooden insulators is to boil them in paraffin. A one-pound block of paraffin is less expensive than a quarter-pint of spar varnish. *Editor.*

references

1. William I. Orr, W6SAI, "Broadband Antenna Baluns", *ham radio*, June, 1968, p. 6.

ham radio