a new multiband quad antenna

This driven array features several improvements over conventional quads for three-band operation

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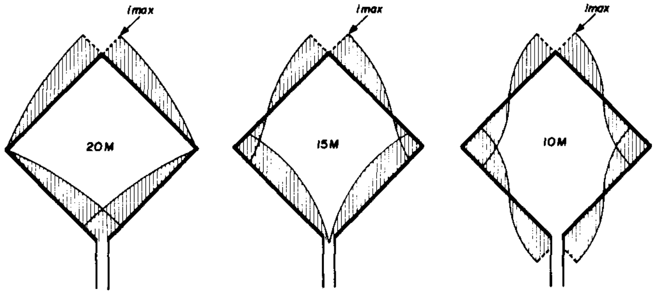
The cubical quad antenna has a reputation among amateurs for being an excellent DX antenna. Even after accounting for claims of over-enthusiastic quad users, the fact remains that the cubical quad is an excellent low-angle radiator, especially where height is limited.

Several ways to build multiband quads have been proposed. Some have proved to be practical and have become popular. All, however, are compromises in one way or another. Before describing the DJ4VM quad, which has been designed to exploit the best features of the quad antenna, I'll review the most popular designs and discuss their disadvantages.

the multiband quad

The most popular multiband quad design consists of nested loop elements on a common supporting structure. Each antenna for each band is supposedly independent, and all are fed with a common transmission line using a gamma matching system or other tricks. The disadvantage here is that the size of the structure, which is determined by the lowest-frequency antenna, is not fully realized on the higher-frequency bands. In the common 20/15/10-meter antenna, for example, the 10-meter loop uses only about 25 percent of the available area.

fig. 1. Current distribution in conventional quad elements (cut for 20 meters). Note displacement of current loop with frequency.



forward field

The forward gain of each of the three antennas is expected to be the same as that of separate antennas of the same loop size. In concentric arrangements, however, the antennas interact. They exhibit spurious responses off the sides and to the rear. It is almost impossible to obtain more than 15 dB front-to-back ratio in the 15-meter antenna when loops are mounted concentrically with 10- and 20-meter loops.[1]

Investigations of single-loop arrangements have been made to simplify the antenna structure and take advantage of the given structure. The loop is usually fed in the lower-half portion; tuning and matching is achieved by stubs or lumped constants.[2,3]

If we consider the current distributions on different bands (**fig. 1**), we can draw the following conclusions:

1. On 20 meters, currents in the upper and lower halves of the loop are **in phase.** The loop thus acts as a broadside array, ensuring low-angle radiation in the desired direction.

2. On 10 meters, the currents in the upper and lower halves are **180 degrees out of phase.** The antenna performs as an endfire array. Enhanced radiation is parallel to the plane of the loop (vertically in this case). This doesn't do much good in long-haul DX work.

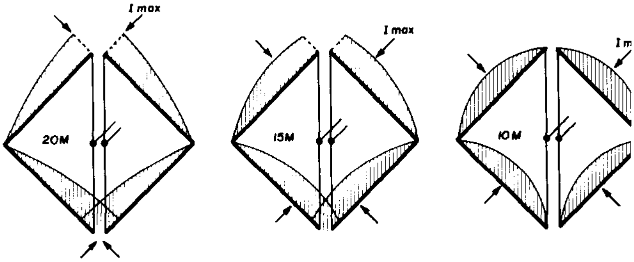
3. In-phase current distribution prevails on the lowest-frequency band; rapid deterioration of performance occurs with increase in frequency.

By introducing stubs, lumped constants, and switching schemes, the proper phase relationships can be obtained on several bands. On ten meters, for instance, the loop can be opened at the top corner, thus converting the antenna into a common bisquare, or so-called inverted rhombic.[4] These designs are feasible but not too practical.

the center-fed loop

To overcome the disadvantages described above, I have developed a center-fed loop element as shown in **fig. 2.** Symmetrical current distribution with respect to the horizontal axis is achieved on all three bands without switching or tuning the elements. Without introducing compromises, the leg length of one edge of the diamond may be between one-quarter and five-eighths wavelength. This will yield a usable frequency range of about 2.5:1 for a fixed loop. Exceeding the maximum length will result in spurious side lobes.

fig. 2. Current distribution in center-driven quad elements. Current loops are always symmetrical.



leg length

The leg length can be less than one-quarter wavelength, but performance will be degraded, part of which is because the current loop is no longer located in the center of each leg. It should be possible to correct this with loading capacitors, as shown in **fig. 3.** However, this means accepting losses introduced by the capacitors.

In general, leg length should be as long as possible, observing the 5/8-wavelength limit. Optimum leg length for a triband antenna would be 5/8 wavelength on 10 meters, or about 22 feet. However, a leg length of 17 feet (1/4-wavelength on 20 meter) would still be a good design, exhibiting only slightly less overall gain.

By settling for less than optimum gain, and sacrificing performance on 20 meters in particular, it is possible to get an element of this kind on a structure that would ordinarily support only a 15-meter quad element and obtain an antenna usable from 20 through 6 meters (12-foot leg length) with excellent performance on 6 meters.

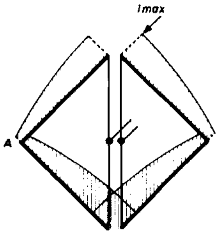


fig. 3. A miniquad element with loading capacitor at A and B.

the DJ4VM quad

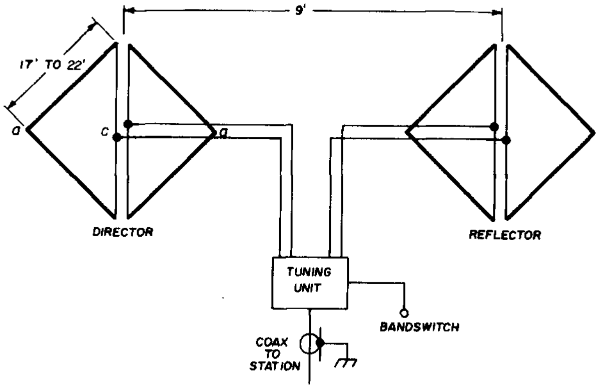
The basic two-element arrangement is shown in **fig. 4.** Two designs were investigated: parasitic reflector and driven reflector. As shown later, the latter has definite advantages. The main one is the greatly reduced need for making a careful compromise in choosing the spacing between the two loops. This is achieved by carefully considering forward gain, front-to-back ratio and bandwidth on all three bands.

the parasitic version

The tuning apparatus for this system is shown in **fig. 5.** Element spacing is 9 feet, with 17 to 22 feet on a leg. The switching can be done either manually or remotely. If you use variable capacitors with a maximum capacity of 50 pF, the coils should have the following approximate dimensions:

20 meters: 10 turns, 1½-inch diameter
15 meters: 8 turns, 1½-inch diameter
10 meters: 8 turns, 1¼-inch diameter

fig. 4. Basic two-element arrangement of the DJ4VM multiband quad.

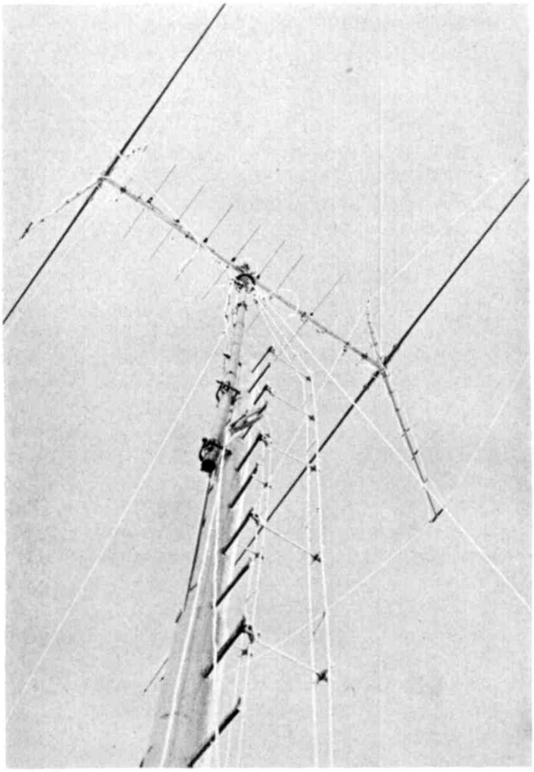


All are spacewound, of course, and preferably self-supporting. Instead of tapping the coils, the coaxial cable could be coupled with a link. Capacitor Ck should be used to tune out leakage inductance.

C1B should be adjusted for maximum front-to-back ratio. Thereafter the setting of C1A should be rechecked and corrected if necessary.

The tuning unit for the dual-driven antenna is shown in **fig. 6,** which is very similar to **fig. 5.** The two elements are driven out of phase by about 180 degrees. The lead length from the branch of the incoming coax to the switch contact, and from there to the coil taps, should be kept reasonably short to eliminate need for transformation. The tap point must be determined by using an swr meter. The approximate tap locations will be as follows (turns counted from the center tap):

20 meters: 2 turns
15 meters: 1½ turns
10 meters: 1 turn



Multiband quad installation at DJ4VM.

For a better adjustment of front-to-back ratio, capacitor Ck can be used. If you do this, the feed point on the reflector coil will change to the opposite side of the center tap (Lb'). It will also be slightly farther away from the center.

Final tuning should be done with a field-strength meter and swr bridge while tuning C1B **in,** C1A **out,** and Ck for maximum attenuation to the rear. It's important to take the time and trouble to do this properly if you want to realize the best performance from this antenna.

Taps for the feed point should be chosen so that C1A and C1B resonate at about the same capacitance (with the transmission line connected and disconnected).

field test results

I don't have any quantitative measurement figures on forward gain. Instead of unsubstantiated claims resulting from wishful thinking, however, I'll give some field test results.

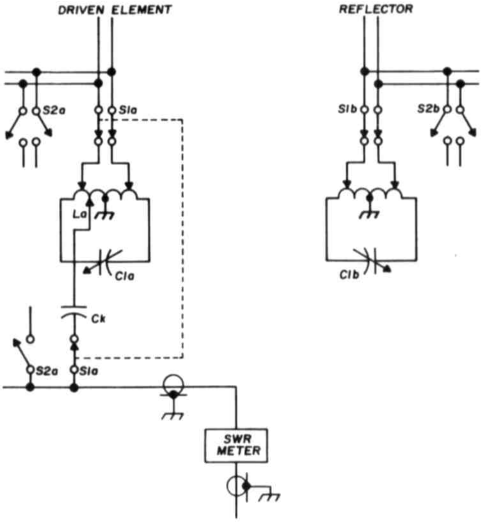
According to reference 5, the beamwidth of an antenna is an indication of forward gain. The half-power points of the antenna described were, from field tests:

20 meters:	50 degrees
15 meters:	40 degrees
10 meters:	30 degrees

Bear in mind this data was taken from my location and will not necessarily be the same for yours. Nevertheless, even under less-than-optimum local geometry, these beamwidths certainly are competitive with most 3-element Yagi antennas. The increased gain (narrower beamwidth) on the higher frequencies results from the larger radiator size, which is a direct consequence of the design principle.

The measured response on 15 meters is depicted in **fig. 7.** The front-to-back ratio was more than 40 dB. Without readjustments in the tuning unit, however, this value can be maintained over a relatively narrow frequency range. **Fig. 8** shows swr, front-to-back ratio and relative gain for the 15-meter band.

fig. 5. Tuning circuit for the parasitic antenna. Switching can be either manual or remotely controlled. Capacitor Ck tunes out leakage inductance.



advantages of the driven antenna

The main advantages of this antenna, compared with other beam antennas in general, are:

1. Utmost flexibility when scrambling for DX contest points.
2. No need to align antenna elements; all tuning is done remotely with the circuits in the tuning unit.
3. Lower angle of radiation for a given height.

fig. 7. Measured horizontal radiation pattern of the all-driven array. Design center is for the 15-meter band.

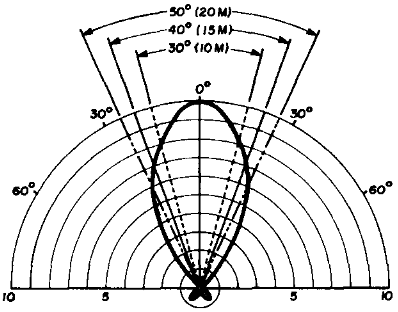
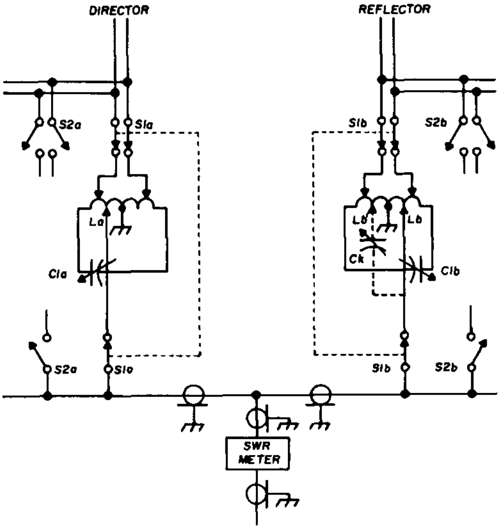


fig. 6. Tuning circuit for the all-driven array. Points La, Lb and Lb' are connected to the coax center conductor. The dashed line between Ck and the coil is an alternative.

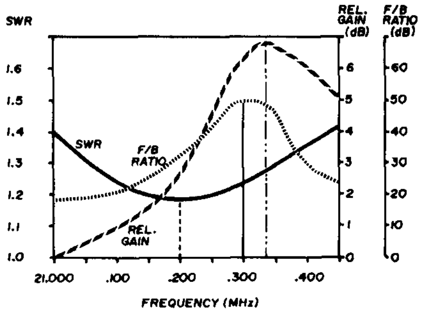


4. Instant 180-degree switching of the beam degrees by switching off the reflector relays. (How long does it take to swing a Yagi from East to West?)
5. Less lateral space required than for a full-sized Yagi, colinear, long-wire and most other horizontally-oriented beams.

a closing note

There's nothing secret about the diamond shape. It was chosen because the vertical feedlines could be easily attached to the fiberglass poles. Other shapes such as squares, circles (for vhf), or the Swiss quad[6] could be adapted as centerfed, multiband quad elements.

fig. 8. Standing-wave ratio, front-to-back ratio, and relative gain versus frequency. The data was taken on the 15-meter band.



The all-driven quad has been tested for some time and has given excellent results. Neither the antenna height (40 feet) nor the location (in a valley) can explain the performance it has given.

references

1. W. I. Orr, W6SAI, "All About Cubical Quad Antennas," Radio Publications, Inc., Wilton, Conn., 1959, p. 50.

2. F. Kneitel, K2AES, "Antenna Roundup," Cowan Publishing Co., Vol. II, p. 44.

3. H. F. Rueckert, VK2AOU, "Dreiband-Eindraht-Cubical-Quad-Element," *DL-QTC* (Germany), 1968/4.

4. Byron Goodman, "Inverted Rhombics and Biconical Beams," *QST*, June, 1949, p. 42.

5. W. I. Orr, W6SAI, "Beam Antenna Handbook," Radio Publications, Inc., Wilton, Conn., 1955, p. 31.

6. R. Baumgartner, HB9CV, "Die Swiss-Quad-Antenne," *DL-QTC* (Germany) 1963/10, p. 454.

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