KØSR has come up with a five-band quad for all seasons, especially Cycle 23. The weather is just about right to add this to your antenna farm.

A Five-Band Cubical Quad For Cycle 23

BY STEVE ROOT*, KØSR

This quad was designed to take advantage of the improved propagation we can expect from the next sunspot maximum. Conditions have already improved since last year, and I wanted to upgrade my antenna situation on 12 and 17 meters. Also, there were mechanical problems with my previous quad[1], and it was time to resolve them.

Design Goals

The objective was to build a quad that would cover all five bands between 20 and 10 meters. It should use the simplest feed system possible, avoiding the use of complicated matching networks or transformers. The design of the antenna should allow it to be constructed by one person. Due to the length of a typical Minnesota winter, it should be rugged enough to not require continued maintenance.

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Electrical Design

There are three active elements on 20, 17, and 15 meters. On 12 and 10 meters there are four elements. The previous antenna didn't work as well as I had hoped on 10 meters, since the elements were spaced to wide. Adding the fourth element on 10 meters has made a *good* antenna into a *very good* one. While

This is the completed beauty, and it performs every bit as good as it looks. (Photos in the article by Ramona Root)

Boom support and turnbuckles for boom sag adjustment.

Quad Element Dimensions			
20 meters	**Reflector**	**Driven**	**Director**
Total length	73'	71'	68' 4 1/2"
Side length	18' 3"	17' 9"	17' 1 1/8"
Attachment	12' 10 7/8"	12' 6 5/8"	12' 1"
17 meters	**Reflector**	**Driven**	**Director**
Total length	57' 5 1/2"	55' 6 1/4"	53' 10 1/4"
Side length	14' 4 3/8"	13' 10 1/2"	13' 5 1/2"
Attachment	10' 1 7/8"	9' 9 3/4"	9' 6 1/4"
15 meters	**Reflector**	**Driven**	**Director**
Total length	49' 1"	47' 1"	46' 3"
Side length	12' 3 1/4"	11' 9 1/4"	11' 6 3/4"
Attachment	8' 8 1/8"	8' 3 7/8"	8' 2 1/8"
12 meters	**Reflector**	**Driven**	**Director**
Total length	41' 8 7/8"	40' 3 7/8"	38' 10 7/8"
Side length	10' 5 1/4"	10' 1"	9' 8 3/4"
Attachment	7' 4 1/2"	7' 1 1/2"	6' 10 1/2"
10 meters	**Reflector**	**Driven**	**Director**
Total length	36' 6 1/2"	35' 2 1/4"	34' 5"
Side length	9' 1 5/8"	8' 9 1/2"	8' 7 1/4"
Attachment	6' 5 1/2"	6' 2 5/8"	6' 1"

Total: The circumference of the element.
Side length: The total length divided by 4.
Attachment: The distance out on the spreader where the wire attaches, measured from the center of the structure.

Table I– These are the element dimensions.

SWR—HF Bands			
Frequency	**20 meters**	**15 meters**	**10 meters**
0.	1.4	1.3	1.4
0.1	1.3	1	1.4
0.2	1	1.3	1.3
0.3	1.25	1.6	1.15
0.4	2.4	1.8	1
0.5	—	—	1.2
0.6	—	—	1.3
0.7	—	—	1.4
0.8	—	—	1.5

Table II– SWR for the HF bands.

the first director has to be spaced fairly close (.12 to .15 wavelength) for a quad to work, the second director can have wider spacing.

In practice the pattern on 12 and 10 meters is outstanding. In addition, by choosing the appropriate spacing, the feed point impedance is close enough to 50 ohms to allow direct feed with coax. There aren't any transformers, gamma matches, or other devices required. A remote antenna switch is used at the feedpoint. Experience has shown that the common practice of tying the different feedpoints together results in matching problems and hurts the pattern of the antenna. The remote antenna switch effectively means that there are separate feedlines running to each driven element. In the past, I used different types of baluns in an attempt to keep currents from flowing on the outside of the feedline. They were either difficult to construct, heavy, or expensive, and in most cases they didn't help! I have to thank Lew McCoy for enlightening me on this subject.

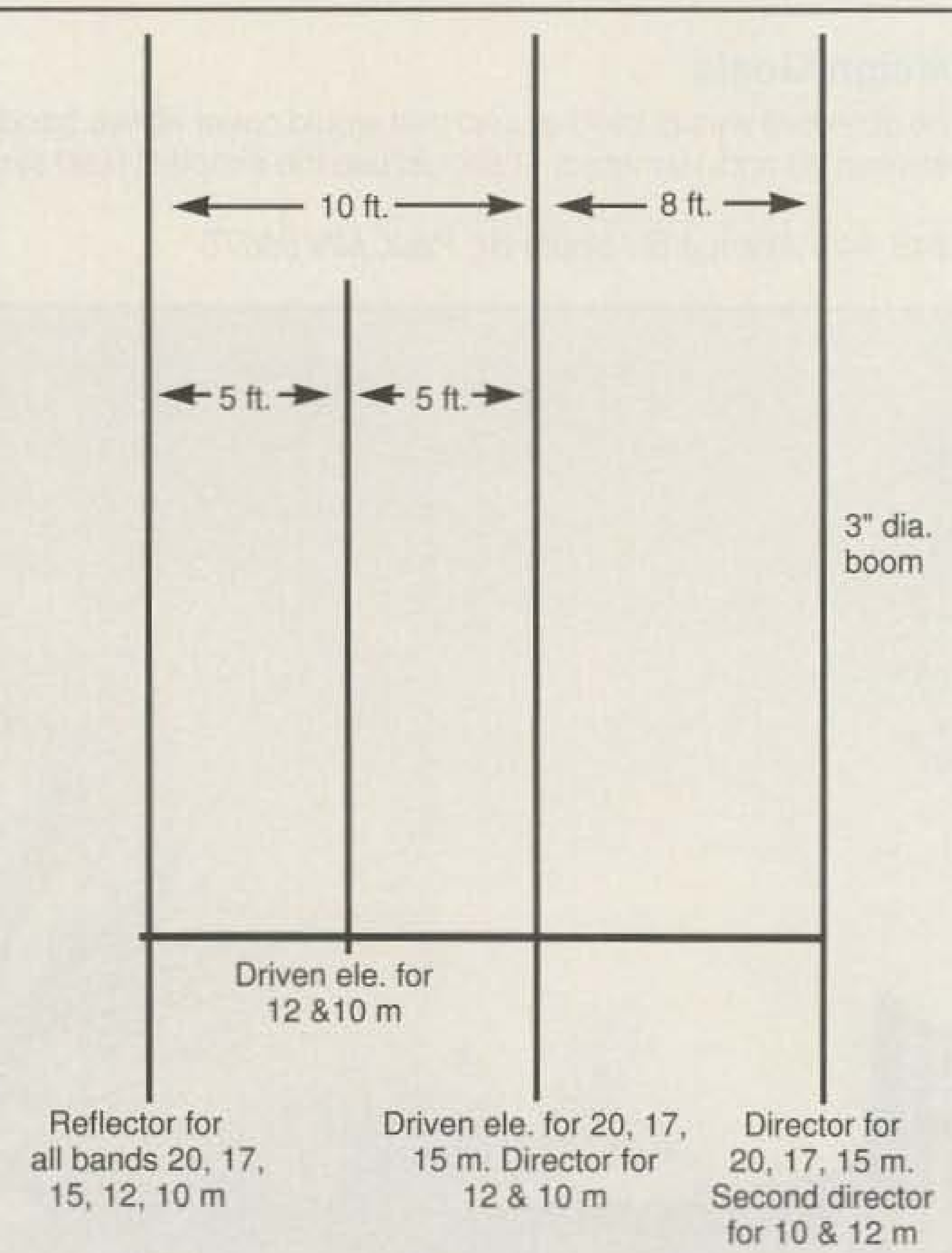
The element lengths I use have more or less become traditional with me. A slight adjustment was made to the 15 meter driven element length to move resonance up the band slightly. The 17 and 12 meter element lengths were extrapolated from the 15 meter element lengths. The resonant frequencies of the parasitic elements are 3% above and below the design frequency of the array. This is due to the lower Q nature of a loop element. Yagi antennas, with their higher Q elements, use more offset.

Mechanical Design/Materials

This antenna, like the last one, is based on an 18 foot boom. There isn't anything magic about this boom length. My tower happens to be 10 feet away from the edge of my roof, so I can reach the end of the boom quite easily during construction and tuning of the antenna. I also favor short booms because long booms are hard on rotors. The boom is a three inch diameter piece of irrigation pipe.

There are two possible orientations for a quad element—square or diamond. Each has its advantages. The square configuration doesn't hang as far down the tower, while the diamond shape seems to hold up better if icing is a possibility. The downward pointing spreader of the diamond also provides a convenient support for the feedlines. I chose the diamond configuration because of my climate.

The previous antenna suffered two spreader failures. Both incidents occurred during violent summer thunderstorms, and in both cases the spreaders failed right above the spreader clamp. It was obvious that there was some movement between the spreader and the clamp, which resulted in a weakening of the spreader wall. As a spreader flexes in the wind, the force is concentrated at that point. Increasing the wall thickness at the



Spacings in Wavelengths

20 meters: Reflector to Driven = .150 λ Driven to Director = .119 λ
17 meters: Reflector to Driven = .192 λ Driven to Director = .153 λ
15 meters: Reflector to Driven = .224 λ Driven to Director = .179 λ
12 meters: Reflector to Driven = .132 λ Driven to 1st Director = .132 λ
1st Director to 2nd Director = .211 λ
10 meters: Reflector to Driven = .150 λ Driven to 1st Director = .150 λ
1st Director to 2nd Director = .241 λ

Fig. 1– Element locations and spacings, side view.

One end of the boom showing the truss end and spreader clamp.

base helps considerably, and the new spreaders do just that. These spreaders were purchased from Max Gain Systems[2] in Marietta, Georgia. They are two-piece fiberglass spreaders made from 8 foot sections that have .125 inch wall thickness. With a 12 inch overlap at the splice, this results in a spreader that is longer than necessary for the 20 meter elements. The excess length was cut off and epoxied into the butt end, giving it a wall thickness of .25 inches. These spreaders are very rigid and behave themselves quite well in the wind.

SWR—WARC Bands			
Frequency	**17 meters**	**Frequency**	**12 meters**
0.06	1.4	0.89	1.1
0.08	1.3	0.91	1.05
0.1	1.2	0.93	1
0.12	1.3	0.95	1
0.14	1.4	0.97	1.05
0.16	1.6	0.99	1.1
0.18	1.9	—	—

Table III– SWR for the WARC bands.

The wire was purchased from The Wireman[3]—their type #CQ-18. This is #18 stranded, copper-covered steel wire that is very light and strong. Compared to the previous antenna, the spreaders are stiffer and the wire is lighter. This one doesn't flop around! The wire in a quad presents a fair amount of windload all by itself, so going to smaller diameter wire is beneficial.

The spreader clamps are Cubex models. On the three larger elements I doubled up on the clamps. This is probably overkill, but I had them available so I used them. Stainless-steel hose clamps and screws were used throughout the antenna. The boom-to-mast plate was fabricated from 5/16 inch thick aluminum plate. To add stiffness to the boom, and to compensate for the weight of ice loading in a winter storm, the boom was double trussed. A short cross boom was mounted to the top of the mast and truss lines were run out to the ends of the quad boom. A single truss would have rubbed against the upright spreader of each element.

Construction

The spreaders are two-piece fiberglass poles that telescope together. The junction of the two pieces is secured with two #6 bolts. As mentioned earlier, a 12 inch section was cut off the far end of the spreader and epoxied into the butt end of the spreader. The end product is very rigid and tough, and that extra wall thickness at the base should eliminate failures. The manufacturer recommends a thorough cleaning followed by spray painting to protect them from ultraviolet radiation. I cleaned the spreaders with acetone and then spray-painted the spreaders flat black. As always, safety first! Do this in a well-ventilated area.

Each element was built on the ground and mounted on the boom one at a time. A calculation was done for each loop to determine side length and also the attachment point on the spreader. The side length is obviously the total length divided by four. The attachment point out on the spreader can be calculated by dividing the side length by the square root of two. Doing this will result in a nice, symmetrical-looking element (it ends up square!). It also helps maintain the correct current distribution in the element, which contributes to a clean pattern.

The wires are attached by tying them down with string, followed by electrical tape, then two cable ties criss-crossed over the top. Drilling holes through the spreader will weaken it and is really a poor way to do things. It is hard to estimate how tight the wires are while the element is lying on the ground. This attachment method allows you to pull a bit of wire one way or the other once the element is in its normal orientation. The wires are tight enough to look good, but not under a lot of tension.

The feedlines were attached to the driven elements while they were on the ground. Soldering the connections is a lot harder to do on the tower. Excess flux was removed, and Coax Seal® was applied liberally to waterproof the assembly.

Individual elements are light enough for one person to carry. I used the roof of my house as a scaffold to reach the end of the boom. No, my tower isn't that short; it's a crank-up! After all four elements were on the boom, they were lined up for appearance sake.

Tuning

A grid dip meter was used to verify the resonant frequency of each element. This is an approximation only, as the proximity to ground will affect resonance, and there isn't any practical way to reach the elements with the tower cranked up. **Don't climb a crank-up tower that isn't all the way down!** In general, the resonant frequency will move up as an antenna is raised. The general shape of the SWR curves shows that the parasitic elements are resonant in the right places.

Results

Physically, the antenna seems to be very sturdy. Unlike other quads I have built, this one doesn't move very much during strong, gusty winds. My old Ham-IV rotor turns this antenna without difficulty.

Initially, I was very concerned about interaction, with all five bands represented on the same structure. The 10 and 12 meter elements in particular are fairly close to each other. It was a pleasant surprise to see all five bands act the way they should. Because loops radiate in a broadside direction, the concentric elements aren't "in the way." This is different than an interlaced Yagi design, where all of the elements are coplanar. This antenna acts like five monobanders.

The SWR is below 2:1 across all five bands. On the three lower bands, where the antenna has three elements, the pattern is good. On 12 and 10 meters, with four elements, the pattern is very sharp. After the quad was first put into service, I stumbled onto a good sporadic-E opening on 10 meters. It was amazing to see an S-9 signal in Florida drop several S-units simply by swinging the antenna from 135 degrees up to 90 degrees. Having this kind of a pattern is wonderful, as it reduces interference from other directions quite a bit.

Performance during contests this past fall exceeded expectations, especially in the ARRL 10 Meter Contest, where the new quad really worked well. Come on, Cycle 23! ■

Footnotes

1. S. Root, "A Compact, 4 band Quad Array," *CQ*, July 1994, p. 22.
2. Max-Gain Systems, Inc., 221 Greencrest Ct., Marietta, GA 30068 (770-973-6251).
3. The Wireman, Inc., 261 Pittman Rd., Landrum, SC 29356 (803-895-4195).