

Design and Construction of a Quad That Will Last

Steve Root, KØSR

A recent thread on the CQ-Contest reflector inspired this article. During a discussion about the relative merits of various multiband Yagis, someone suggested the 2-element quad. I've been building and using quads since 1969 and would like to share my experiences. I make no claim to have discovered anything revolutionary about the electrical design of these antennas. W6SAI, W1ICP, W4RNL, N6BV and many others have published lots of material on quad design, and I'm indebted to them for what understanding I do possess. My emphasis here will be on mechanical design — keeping your quad in the air and working for you.

Applications — Quads vs Yagis

When examining the application of a certain type of antenna, we have to look at compromises, both electrical and mechanical. Big, long-boom, multielement monster quads are great antennas, but if they were the ultimate answer, then K3LR and KC1XX would be using them. While the electrical performance of a large quad is impressive, the mechanical trade-offs are just not favorable when compared to a Yagi.

On the other hand, where space and resources are limited and the goal is good performance over multiple bands, a small quad works very well. A 2-element quad is approximately equivalent to a 3-element monoband Yagi, exhibiting respectable gain and useful directivity. Either antenna is an excellent performer in its own right, however.

When it comes to ease of assembly, the multiband Yagi has a small edge, while the quad can exhibit better performance across several bands. With the proper choice of materials and construction techniques, either antenna can stand up to the weather.

A trapped 3-element Yagi compromises in terms of element spacing, boom length and element length, not to mention losses associated with the traps and other factors. There is also the question of power-handling capability, especially when running high duty cycle modes like RTTY. An interlaced Yagi will have coplanar elements on the boom that are in the way when operating on a given frequency. The common solution is deliberately mistuning elements to limit interaction. Typical feed point impedances are well below 50 Ω , necessitating some sort of impedance transformation. This can introduce additional losses.



Figure 1 — Cubical quads, like this one assembled by the author, can last a long time by using the proper construction techniques.

A 2-element quad has full-sized elements. Since a loop radiates broadside, concentric elements are not in each other's way. The biggest compromise with a 2-element quad is in terms of boom length/element spacing. Using a "spider" quad, such as the Gem Quad, is one way to address this issue. Feed point impedances are in the neighborhood of 50 Ω , eliminating the need for impedance matching, and a quad element will handle 1500 W all day without getting warm.

You'll sometimes hear the claim that quads "open the band earlier." This suggests that quads exhibit a slightly lower angle of radiation than Yagis. I know the computer models don't agree with this, yet the perception has persisted for 50 years. I may have an explanation for this, however.

We know from experience that a single loop for the low bands (80 or 160 meters), fed correctly, will have a low angle of radiation — much lower than that of a dipole. This establishes that a loop can radiate at a low angle, regardless of its height above ground. A quad loop is basically two dipoles stacked one-quarter wavelength apart. The wire on the sides of the loop acts like a parallel conductor feed line to

get power to the other dipole. This parallel conductor also has quarter-wavelength spacing, which makes it lossy. The losses in this case aren't in the form of heat but radiation. As I see it, the resulting, small cross-polarized component radiating from the quad element is at a low angle, and this explains why quads have the reputation of superior performance at low heights. I may be all wet, but I've reached the top of the Honor Roll and won contests with a quad on top of my 55 foot tower, so *something* good is happening.

In 1999 John Moulder, KØXN, asked me to help him construct a 2-element quad. I wasn't sure of the element dimensions, because the quads I had been building and using were 3 or 4-element designs. The presence of a director has a big impact on the size of the driven element, when compared to a driven element/reflector quad configuration. KØXN did a lot of tuning and tweaking before attaining the performance he wanted.

About this time I purchased a copy of *The ARRL Antenna Book* and was interested to see a design for a 2-element quad.¹ This design was based on a careful computer modeling study. I was surprised to discover that the dimensions



Figure 2 — A cardinal rule in quad design is to avoid tying all the elements together in the middle of the quad. Instead, use a remote antenna switch to swap the feed line among elements for each band.

Table 1

Recommended reflector, driven element, and feed line lengths for a 2-element quad

Band	Reflector	Driven Element	Feed Line
20 meters	72 ft, 4 in	69 ft, 10.5 in	23 ft, 0.375 in
17 meters	56 ft, 4 in	54 ft, 10.5 in	17 ft, 11.25 in
15 meters	48 ft, 6 in	46 ft, 7 in	15 ft, 4.75 in
12 meters	40 ft, 11.25 in	39 ft, 10.5 in	13 ft, 0.5 in
10 meters	37 ft, 5.5 in	34 ft, 6 in	11 ft 5 in

These dimensions assume you're using bare wire. Reduce the size of the loop by 1 to 2 percent for insulated wire. I haven't added any extra length to allow for a mechanical connection either. The feed lines are sections of coax between the feed point of the antenna and the remote antenna switch. The dimensions listed are electrical half-wavelengths for each band, assuming a velocity factor of 0.66.

in *The ARRL Antenna Book* numbers and those KØXN arrived at experimentally were within 1 percent of each other. Needless to say, I feel confident that these represent a workable set of element dimensions for a 2-element quad on an 8-foot boom.

Design Considerations

Here are six things I recommend taking into account when designing a quad, plus one requirement I insist upon. The most common mistake with quads is tying all the feed points together. While this seems like the simple way to do things, the result is very poor performance, especially in terms of the pattern. Experience and extensive computer modeling bear this out.

The best solution is to use a remote antenna switch. Set the switch up to ground unused ports, and use an electrical half-wavelength of coax between the feed point and the appropriate port on the

remote switch. Don't worry about baluns or chokes unless you are extremely unlucky and happen to have a resonant length of feed line running up the tower.

Element lengths aren't particularly critical, since quad loops exhibit a lower Q than do Yagi dipole elements. Take reasonable care when cutting elements to length, and keep everything square.

The majority of failures I experienced early on were due to the destructive effects of ultraviolet (UV), something you can avoid with the proper choice of materials.

Don't string the antenna like a big banjo. The wind is going to blow, and things are going to move. Trees move and stay up; if your quad can move, it will stay up, too.

You can configure a loop element to look like a square or a diamond, also called a "delta loop" and therefore not truly a "quad." Electrically speaking, the two configurations are the same. Mechanically speaking,

the square configuration doesn't hang down the tower as far, while the diamond configuration comes strongly recommended for areas where icing can occur. Water collects on the horizontal legs of the square configuration, while it tends to drip off the diamond.

Choice of Materials

Selecting the right materials is crucial to building a quad that will last. Here are my recommendations on what materials to use.

Wire: Besides comprising the actual antenna in a quad, wire is an important structural component. Bare or insulated wire will work, but since stretching and flexing are major considerations, I prefer insulated, *stranded* wire.

If you use insulated wire, downsize the elements by about 1 or 2 percent. Insulated wire has a lower velocity factor than bare wire, so a resonant element will be physically smaller.

Polyethylene insulation sheds water very well and helps keep the antenna up during winter storms. It does have a higher wind-loading area — do the math; it's not insignificant — but it's worth it in climates like mine in Minnesota. It's also more visible to birds. My previous quad used 18-gauge stranded wire, which was marvelously light and had low wind resistance. About once a month, however, I'd discover a dead bird at the base of the tower and a broken wire. My present antenna uses AWG 13 insulated wire from The Wireman (product number 531). I haven't broken a wire yet, and I haven't found any dead birds either.

Spreaders: Everything from bamboo to railing poles to pole vaulting poles has been used. Don't use aluminum or any other conductive material, however. Commercially available heavy-duty spreaders have gotten much better over the years and work well. I use Type I fiberglass spreaders from Max-Gain Systems, www.mgs4u.com/. The spreaders have a flat black finish to help protect them from UV.

Boom: My earlier quads were longer, multi-element designs that used a 3-inch boom. Constructed from materials recycled from previous antennas, my current quad has 2 elements on an 8-foot boom, so the 3-inch material — a piece of aluminum irrigation pipe — is probably overkill. A piece of heavier-walled 2-inch aluminum should be adequate for a 2-element quad.

Boom-to-spreader clamps: Cubex sells one-piece spreader clamps that work very well. I've been using these same clamps for many years and haven't had occasion to try anything else.

Hardware: It's well worth the expense to use stainless steel hardware. Be careful when buying hose clamps, however. The strap may be stainless, but the screw frequently is not. When it inevitably rusts,



Figure 3 — Don't drill holes through your spreaders. Hold the wires in place on the spreaders and secure them with a piece of string. Then wrap the string with electrical tape and use a UV-resistant cable tie to keep everything in place.

you can't remove it without destroying the clamp.

Construction Techniques

One of the biggest *perceived* drawbacks to the quad is that its three-dimensional nature renders it unwieldy. Once the antenna is atop the tower, it really doesn't matter how it's shaped, and you can simplify the process of getting it up by doing the job in stages. I've always mounted the boom, the remote antenna switch and the boom-to-mast plate on the tower first. Then, I construct the elements on the ground — preferably in a place that's at least 15×15 feet and flat. The elements are two-dimensional and no more difficult to move around by themselves than a Yagi. Mount the elements on the boom one at a time.

Next, use hose clamps to fasten the spreaders to the spreader clamps. Make them snug, but *not* so tight that they crush or score the spreader. I've seen spreaders fail right above the second hose clamp, suggesting the spreader was damaged during construction and later failed at that point.

To attach the wire to the spreader I use an idea I first saw described by Landskov² in *QST*. Don't drill holes through your spreaders. Hold the wire in place on the spreader and then tie it down with a piece of string. I use chalk line because it's inexpensive, strong and available at any hardware store. Cover the string with black electric tape, then use a UV-resistant

cable tie to hold the tape in place. This method avoids sharp stress points at the corners, which can lead to wire breakage, and it allows for some movement of the wire through the attachment point under extreme conditions. It also lets you adjust tension between spreaders.

When cutting element lengths, allow a few extra inches so you can make a solid mechanical attachment at the splice (the point at which you close the loop). Shift the wire position to get that splice away from the corner. This helps avoid a potential failure point down the road. A twisted soldered connection isn't as tough as a straight section of wire.

The feed point requires special consideration. If you're using the diamond configuration (recommended), then the feed point will land on a spreader. You'll need to factor in the extra length from the coax attachment at the feed point. The two or three inches of split will add to the overall length of the loop. This isn't a huge problem on 20 meters, but it's very noticeable on 10 meters. I form small loops on the ends of the wires, use string through the small loops and around the spreader then solder the feed line to the wire next to the loop. I use a hemostat or a pair of needle-nose pliers as a heat sink. Then I tape it all up and cover it liberally with Coax-Seal or equivalent.

Summary

A 2-element quad is small and compact. Minimal design compromises ensure high

Table 2 — Quad manufacturers

Cubex Quads
PO Box 352
Alto, MI 49302
(616) 868-9907
www.cubex.com/

The Wireman
261 Pittaman Rd
Landrum, SC 29356
(800) 727-4195
www.thewireman.com

Ameritron
116 Willow Rd
Starkville, MS 39759
(662) 323-8211
www.ameritron.com

efficiency, and building it using quality materials and good construction techniques will result in a reliable antenna that will provide years of service. It may be the answer you've been looking for!

Notes

¹*The ARRL Antenna Book*, 21st ed, p 12-9, "A Two-Element, 8-foot Boom Pentaband Quad"

²Landskov, Hardy, "Evolution of a Quad Array," *QST*, Mar 1977, p 32

