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The TriMox — A Moxon Tribander for a Holiday DXpedition

For the past five years, I've traveled to the Caribbean to "be DX" in the Single-Operator, All Band, Low Power category of the annual ARRL International DX Contest phone event. While trying to erect effective antennas at four different locations — and not succeeding to my own satisfaction — I've learned some hard lessons about the need for a lightweight, compact, unidirectional antenna that covers 10, 15, and 20 meters and can be raised with a single support.

With just 6 weeks to go before this year's February departure, a period punctuated by two more full-weekend contests in which I planned to participate, I still didn't have a solution. The Moxon rectangle,[1] first described by Les Moxon, G4XN (SK), and the wideband hexbeam,[2] developed by Steve Hunt, G3TXQ, were strong contenders. Being driven to achieve the maximum "fun per dollar" from my hobbies, I inventoried the materials on hand and decided to attempt a triband array of Moxon rectangles.

L.B. Cebik, W4RNL (SK), detailed the history and benefits of the Moxon rectangle in *QST*:[3]

- Gain similar to a 2 element Yagi, with very good rejection of rearward signals and 25 percent smaller turning radius
- About 80° forward horizontal beamwidth with gain and F/B pattern integrity across at least one-half of each amateur band
- Low SWR across each full amateur band, using wire element construction

In contrast to W4RNL's suggestion to support the Moxon rectangle from two or four poles, contributors to the Moxon Antenna Project website[4] created by John Labutski, KD6WD, (SK), have built lightweight X frames that allow the antenna to be raised and supported from a single, central point. With a good deal of antenna modeling experience under my belt, I chose to use the *EZNEC+* interface to the *NEC-2* computing engine to develop the antenna, rather than attempting a trial-and-error approach with hardware prototypes.

It has long been recognized that interelement coupling makes adapting the Moxon rectangle to multiband use a nontrivial problem.[5] While there are reports of progress in this area,[6,7,8] I was unable to

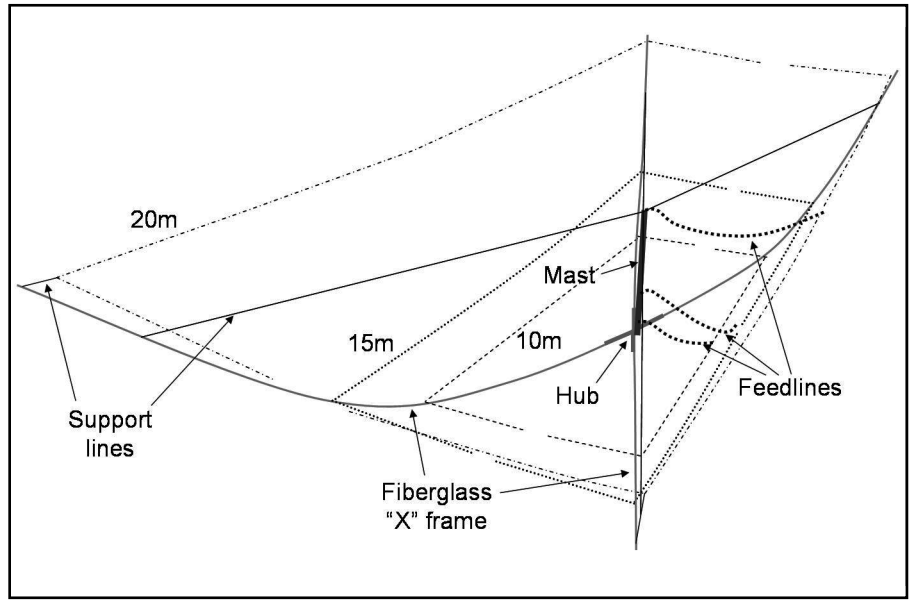

Figure 1 — Diagram of triband array of Moxon rectangles.

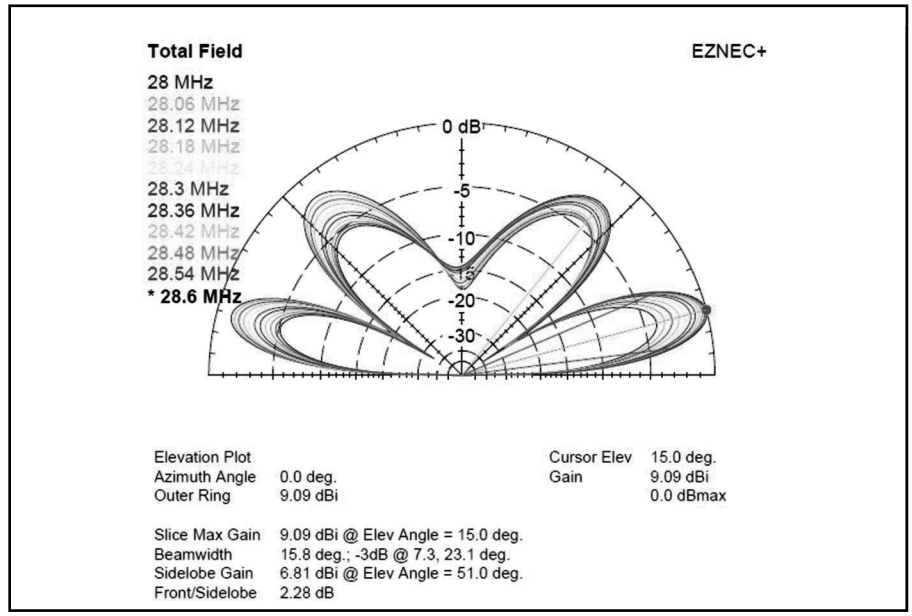

Figure 2 — Elevation plot of triband 10 meter Moxon rectangle with series feed

arrive at working models of these designs in time for my impending trip, so I struck out on my own in search of a simple, workable solution.

Design

After computing dimensions for the three elements using *MoxGen,*[9] my first effort to reduce inter-element interaction followed a key principle of the wideband hexbeam: Use an inverted umbrella-type structure to create vertical separation between the elements (see Figure 1) With the smallest (10 meter) element at the bottom, the 15 and 20 meter elements are spaced 6 inches and 3 feet above the 10 meter element, respectively. Again following G3TXQ's lead, I fed the three elements in series. Despite feeding the elements in different orders and varying the line lengths between the elements, the 10 meter pattern and the SWR on all bands deteriorated beyond what I considered to be useful (see Figure 2), — and the clock was ticking.

Recalling past information I'd read on the use of transmission line stubs to reduce harmonic inter-station interference at multitransmitter stations,[10] I wondered if I could detune the unused elements by connecting them to open-circuit half-wave transmission lines. This would present a short circuit at the elements' feed points at the stubs' resonant frequencies. After examining the strongest inter-element interactions, I determined that feeding the 10 and 20 meter elements with 15 meter half-wave lines and feeding the 15 meter element with a 10 meter half-wave line provided the cleanest set of patterns for the three bands.

The elements' individual feed lines would be connected to a remote coax switch mounted on the mast and controlled from the shack. I used open-circuit half-wave

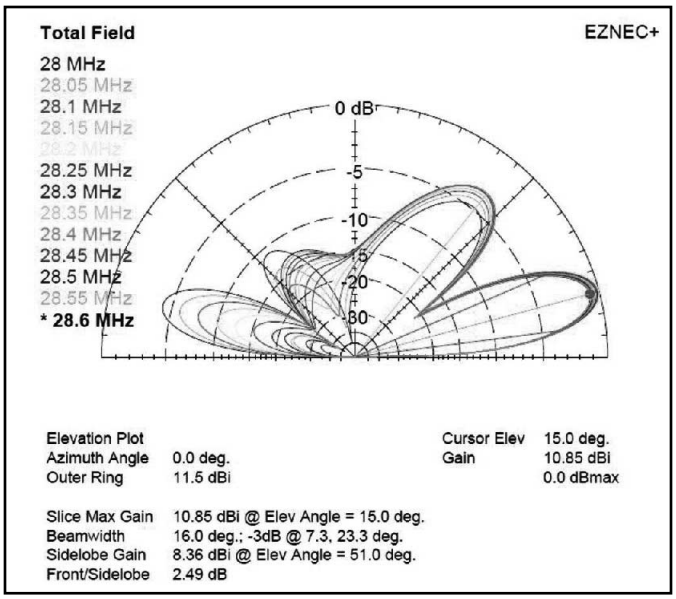

Figure 3 — Elevation plot of triband 10 meter Moxon rectangle with stub feed

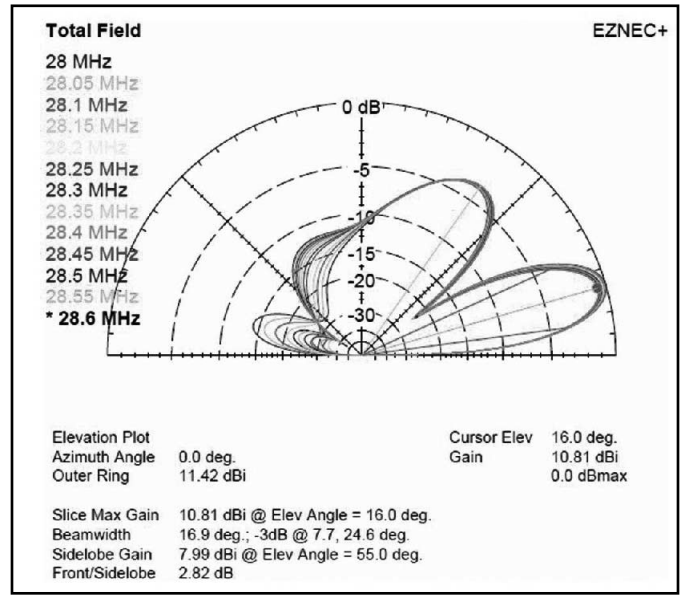

Figure 5 — Elevation plot of triband 10 meter Moxon rectangle with stub feed and increased total vertical spacing

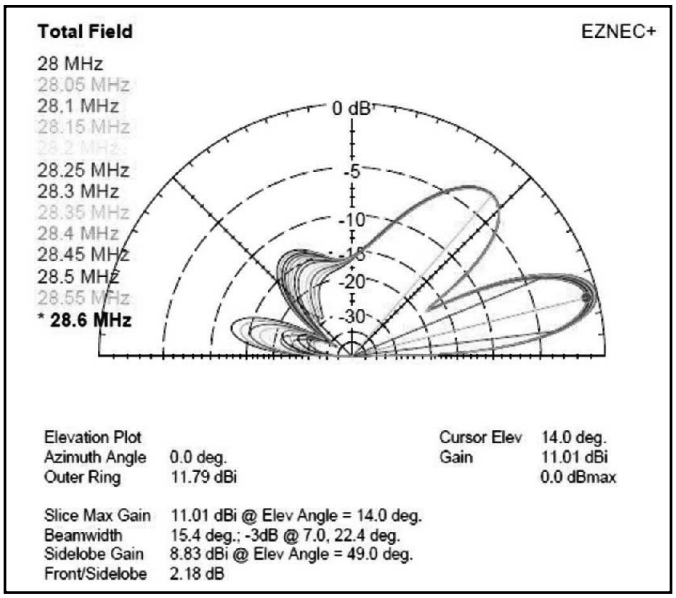

Figure 4 — Elevation plot of monoband 10 meter Moxon rectangle

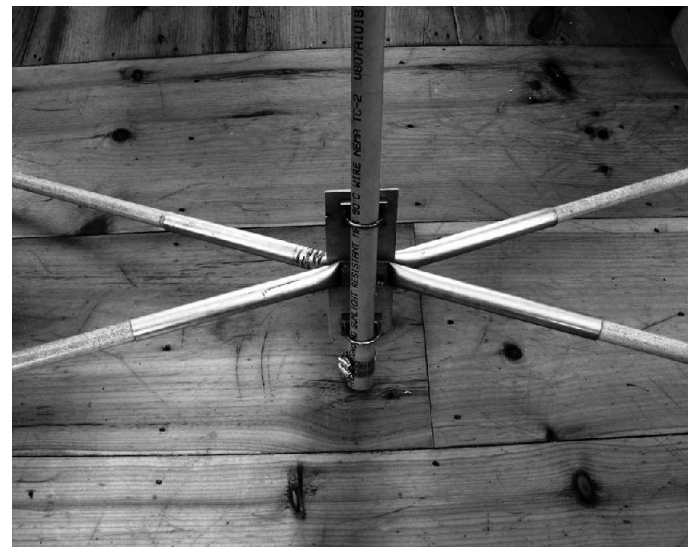

Figure 6 — TriMox hub and mast assembly [K1LI photo]

lines, because I wanted to use the remote coax switch I had on hand. With a shorting coax switch, it might be possible to use short-circuit quarter-wave lines to reduce cost and weight.

There was still one catch, though. The 10 meter pattern bandwidth (see Figure 3) was considerably narrower than it would be for a monoband unit (see Figure 4). Increasing the total vertical spacing between the elements to 5 feet restored the pattern integrity (see Figure 5). Finally, it was time to *build* the antenna.

Construction

A local metal shop cut, pressed and bent 1 inch heavy-wall electrical conduit to form the arms of the hub that receives the mast ends of the four spreaders.[11] I was keen to bring the antenna on an airplane as checked baggage, so all components were broken down into four foot lengths. Each spreader comprises 4 foot lengths of pultruded fiberglass tubing with 0.125 inch walls.[12] Tubes of 1 inch diameter fit into the four hub arms. Three 0.75 inch tubes are internally spliced together with 0.5 inch tubes and secured with hose clamps. This 12 foot long subassembly is inserted into the 1 inch tube with 6 inches of overlap and secured with a hose clamp. So, each spreader is 15 feet long.

To minimize weight and maximize portability, I crimped and soldered ring terminals to the ends of the Flex-Weave™ half-elements and tied Dacron line to the ring terminals to create the critical gaps between the driven elements and reflectors for the respective bands. With the corners of the 20 meter element secured to the ends of the four spreaders, they assume a shape that allows placement of the 15 and 10 meter elements in positions that are very close to the model. I secured a 4 foot mast of PVC electrical conduit to the hub with an aluminum hub-to-mast plate and added low-stretch Dacron lines from the top of the mast to each spreader to relieve some of the stress on the 20 meter element (see Figure 6).

I took two precautions to minimize pattern distortion that might result from interactions between the antenna elements and the three feed lines. At each element's feed point, I wound two turns of the RG-8X feed line through a Fair-Rite 2643102002 Type 43 ferrite bead secured to the Lexan rectangle that serves as the center insulator. I also coiled the excess feed line from each element and secured the coil to the mast, leaving a short lead to the coax switch.

First checks of the antenna produced mixed results. With the antenna sitting on sawhorses a few feet above the ground, the 20 and 15 meter resonant frequencies were shifted up by more than 100 kHz, as expected. But the 10 meter resonant point was shifted down by more than 300 kHz. Suspecting that the hub assembly might be detuning the 10 meter element, I reversed the vertical positions of the 15 and 10 meter elements (see Figure 7). SWR measurements confirmed the hoped-for results, and this rearrangement of the elements slightly improved the modeled 10 meter pattern, while the simulated azimuth patterns demonstrated no disruption of the pattern on any band (see Figure 8). With the antenna still on sawhorses, I made some 20 meter contacts around the US and as far as Japan with good reports, as well as a few contacts on 15 and 10 — including 3D2RX on 15 CW. Rotating the antenna at ground level while listening to stations in Ontario and Newfoundland, Canada on 20 CW confirmed the desired F/B performance.

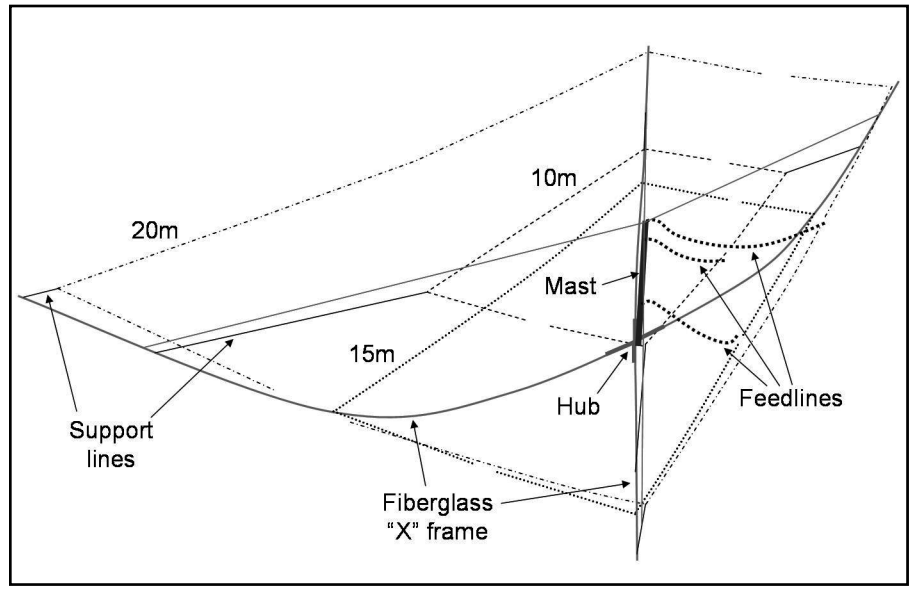

Figure 7 — Diagram of revised triband array of Moxon rectangles

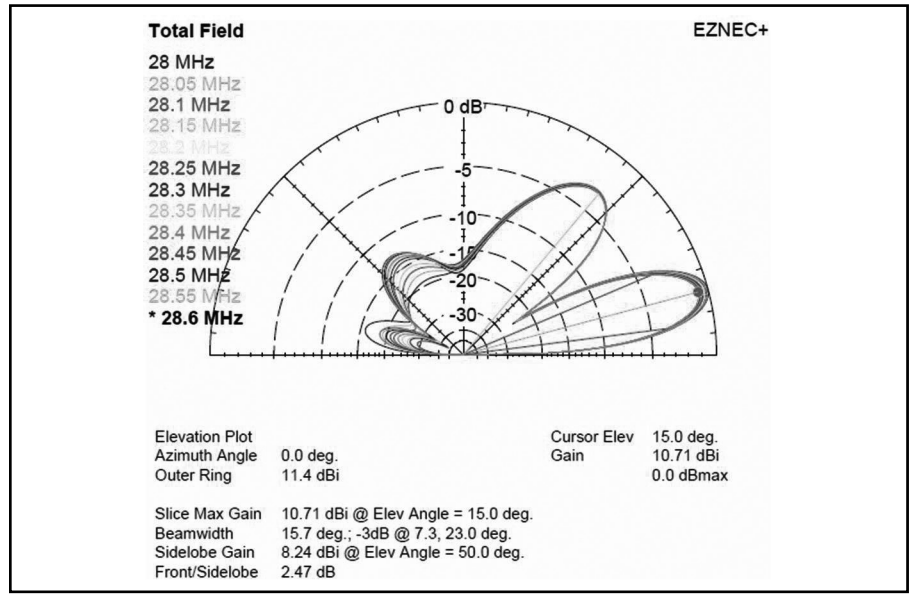

Figure 8 — Elevation plot of revised triband 10 meter Moxon rectangle with stub feed

With the exception of the remote coax switch, the entire antenna fits into a cardboard container 48 × 6 × 6 inches, just within the airline's 61 inch linear dimension limit for checked baggage. While the box seemed quite robust when stuffed with the antenna components and sealed at the ends, I reinforced all seams and added several radial wraps of Gorilla Tape to ensure a trouble-free passage. Time to head south!

To the Beach!

Our first morning in Belize dawned warm and windy, with a breathtaking view of the

Figure 9 — TriMox supported on cabana roof beneath makeshift wooden tripod [K1LI photo]

turquoise Caribbean Sea just 50 yards to the east of our second-floor balcony. Unfortunately, the antenna situation was not so pretty. No tall trees were within reach of our cabana and, while the space above the tin roof was overspread with a tangle of branches from the surrounding trees, none reached out far enough to support the TriMox footprint. I found three 10 foot wooden poles leaning against a tree, carried them up a ladder and onto the cabana's roof, then lashed them together into a tripod.

After assembling the TriMox at ground level, the groundskeeper and I lifted the 25 lb antenna onto the roof of the cabana. I positioned the makeshift wooden tripod over the TriMox and hoisted the mast into place (see Figure 9). With this arrangement, the topmost (20 meter) element was nearly 10 feet above the tin roof and 35 feet above ground level, but also facing directly into a wide line of metal-roofed condominiums just 25 feet away. While this "tin canyon" didn't allow the TriMox to perform to its full potential, I was able to make more than 1800 contacts on 10, 15 and 20 during the 2013 ARRL International DX phone contest, including 6 hours at more than 150 contacts per hour. While I was running just 100 W, the TriMox allowed me to hold my own in very crowded band conditions.

A version of this article originally appeared in the June 2013 YCCC Scuttlebutt. *It appears here with permission.*

Notes

[1] Moxon, Les, *HF Antennas for All Locations* (RSGB, 1982), pp 67, 168, 172–175.

[2] Hunt, Steve, *G3TXQ Broadband Hexbeam,* 2007-2013 **www.karinya.net/g3txq/hexbeam/broadband/**.

[3] Cebik, L.B., "Having a Field Day with the Moxon Rectangle," *QST, v*ol. 84, no 6 (June 2000), pp 38–42.

[4] The Moxon Antenna Project, **www.moxonantennaproject.com**.

[5] Cebik, L.B., *Multi-Banding the Moxon Rectangle,* 1999, **w4rnl.net46.net/mbm.html**.

[6] Todorovic, Andra, "YU1QT 6-Band Moxon," **www.moxonantennaproject.com/yu1qtmoxon.htm.**

[7] Todorovic, Andra, "3 Band 3 Element MOXON with single coax feed," **www.s55m.com/teh/3BMOX/3b3lmox.html.**

[8] Croft, Phil, *Phil's Multi-band Moxon,* 2003, **www.moxonantennaproject.com/G0WSPmoxon.htm**.

[9] Download MoxGen from the Moxon Antenna Project, **www.moxonantennaproject.com/design.htm**.

[10] See, for example, K3NA's "Stub Sketch Notes" **www.yccc.org/Articles/K3NA_stubs.pdf** and §20.3 of the 2013 *ARRL Handbook for Radio Communications*.

[11] See example hub designs at **www.moxonantennaproject.com/hubs.htm**.

[12] See, for example, MaxGain Systems at **www.mgs4u.com.**