www.wvara.org January 2013

The Heterodyne

Newsletter of the West Valley Amateur Radio Association

January Meeting

"DXpeditioning for Newbies"
by George Williams, N6NKT

Wednesday January 9
Meeting Starts at 7pm

Meeting Location:
American Red Cross
Silicon Valley Chapter
2731 N. First Street at Plumeria Dr
(southwest corner) in San Jose

Map at www.wvara.org/meetings.html

WVARA Repeaters (W6PIY)		
Band	**Frequency**	**PL**
6 Meters	52.580- MHz	151.4 Hz
2 Meters	147.39+ MHz	151.4 Hz
1.25 Meters	223.96- MHz	156.7 Hz
0.70 Meter	441.35+ MHz	88.5 Hz
0.23 Meter	1286.2- MHz	100 Hz

Club Net

WVARA's club net is on the W6PIY repeaters each Tuesday at 8:30 pm. All repeaters are linked together during the net. The net script can be found at www.wvara.org/net.html .

Visitors Are Welcome!

About the Meeting Speaker and Topic

Did you hear the pile-ups calling 3D2C last September? Then mark your calendar because this month's WVARA meeting will be really cool. George Williams, N6NKT, will be speaking about his experience as a participant on the Conway Reef DXpedition (3D2C). George's presentation, "DXpeditioning for Newbies", will describe what it is like when a local ham goes on a DXpedition for the first time -- including highlights of the 3D2C DX-pedition with Newbie twists and lessons learned.

George was first licensed 1987. After a few years on UHF/VHF, he took his first micro Xpedition to Inyo County, Horton Creek Parkas part of the Calif QSO Party. Then the HF bug really bit him. Currently, George has confirmed over 181 countries via LoTW and QSL cards and has three DXCC awards, Mixed, Phone and CW. He is currently working on Digital and has 70 countries confirmed.

DXpeditioning for Newbies - 3D2C Photos

George-N6NKT Tests Radios During the Voyage

Getting Pre-assembled Antenna Pieces Ashore

The Team Sets Up 1 of the 4 Yagi Antennas

A Shack With the Best View in the World!

Membership Renewal Reminder

Don't forget to renew your WVARA membership. The fastest and easiest way to renew is with Paypal - go to http://www.wvara.org/membership.html and select a Pay Now button. After logging into Paypal, please open and fill in the box on the left titled "Name, Call Sign, Address, Phone, Email". Or bring a check or cash to this Wednesday's meeting. Checks can also be mailed to WVARA, P.O. Box 6544, San Jose, CA 95150-6544.

The K6EI Half Square Yagi - - a High Performance, Low Cost Design for Low-Band DXing

by Jim Peterson, K6EI
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Sun spot numbers are dropping, and it's time to start thinking about low-band DXing. Here's a simple, inexpensive design for 40 meters that handily outperforms a conventional 2 element monobander at moderate heights.

Predawn radio contacts across the Pacific on the low bands are a real kick. The ideal antenna for this kind of activity, however, requires a low angle of radiation as well as solid front-to-rear and front-to-side ratios to minimize stateside QRM. This can be especially true on 40 meters where the additional interference from European broadcast stations can be severe.

This article describes a design (Figure 1) that meets all these requirements by combining a half square radiator with a parasitic reflector. The result is the half square yagi -- an inexpensive vertically-polarized antenna that requires no external phase matching units or radial system, out-performs a conventional yagi mounted at moderate heights, and can be strung up between trees in a typical suburban backyard.

The Traditional Half Square

The conventional half square has been popular for over half a century[iii] and is equivalent to the antenna in Figure 1 minus the reflector. The half square consists of two λ/4 vertical wires, spaced λ/2 apart and fed in-phase by the top wire. It produces a bi-directional pattern (perpendicular to the plane of the antenna) with a gain of about 3 dB relative to a single λ/4 vertical[iii]. The feedpoint is typically at an upper corner with coaxial cable (i.e. current fed at a low impedance point) or impedance matched and fed at the base of one of the vertical wires.

Unlike base-mounted λ/4 verticals, the half square requires no radials. And since the current maxima (the portions of the antenna that do much of the radiating) are up high, absorption by surrounding buildings and other structures is minimized -- not to mention reduced RF exposure to neighbors, family members, and the radio operator.

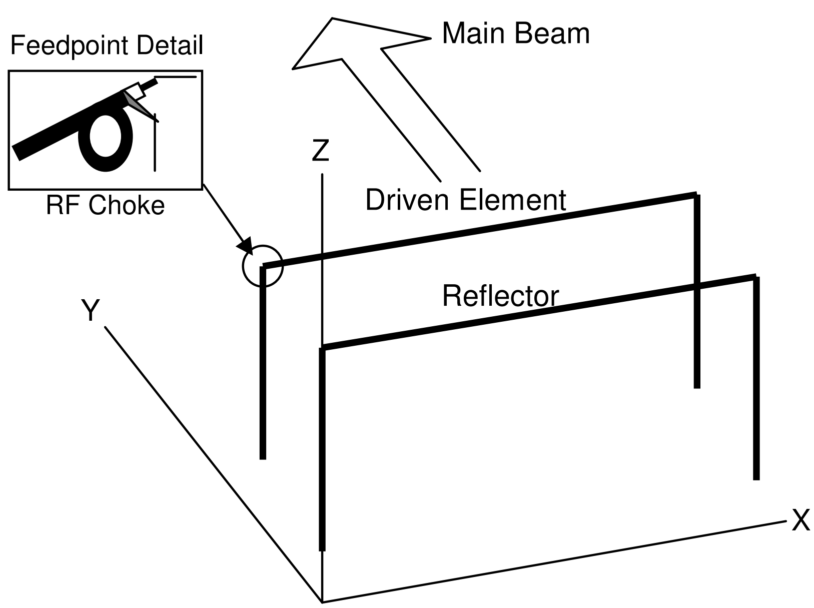

Figure 1. The half square yagi

Improving on a Good Idea

A few years ago in QST[ivv] Paul Del Negro, N2PD, described an innovative method of achieving a uni-directional pattern with the half square by actively feeding two identical half square elements and using active phase control to create the null to the rear. The phased array feed method achieves its forward gain and reverse-side null by separating the two half square elements by $\lambda/4$ and feeding them 90 degrees out of phase. While N2PD's elegant design performs well, it has one practical shortcoming -- the N2PD phased array design requires an external phasing system including a weather-proofed, phase matching device with multiple HV tuning capacitors. (Note: If you are running a full 1.5 kW, the voltage drop across the tuning capacitors in the phase matching unit can reach 4 kV[vi]!)

In contrast, the half square yagi described in the present article does not require a phase matching device, produces comparable radiation patterns, takes up less physical space[vii], and does not require a second feed point[viii].

Two attributes of the half square yagi are particularly effective for low band DX: 1) its excellent front-to-rear ratio and 2) its low angle of radiation.

Excellent Front-to-Rear Ratio

Interference has been a challenge to radio amateurs since the beginning of the hobby. A common remedy (especially on the upper HF bands) is to use a horizontally polarized yagi. Unfortunately, this approach has series of limitations when attempted on the low bands. A low band yagi is large and cumbersome, and getting one more than a fraction of a wavelength above the ground is difficult and costly on 40 or 80 meters. And at low heights, near-field effects can severely degrade the front-to-side radiation pattern[ix x].

The half square yagi provides excellent front-to-rear and front-to-side signal rejection. Signals to the side are down about 23 dB, while the signal suppression to the entire rear quadrant is consistently better than 25 dB. Forward gain at center frequency is 9 dBi with a 3 dB beamwidth of 60 degrees. Figure 2 compares the azimuth pattern at a 15 degree elevation angle for a half square yagi up 45 feet (i.e. with the bottoms of the vertical wires about 10 feet off the ground) with the pattern of a conventional two element yagi at the same 45 foot height. The most significant difference apparent in this plot is that the half square yagi provides a full 15 dB more rear quadrant suppression than does the conventional monoband yagi. In addition, the half square yagi provides 3 dB more gain at this elevation angle than the conventional yagi (more about this shortly.)

Good gain and excellent interference rejection to the back and sides are only the first two major advantages of the half square yagi. A third major benefit of this design is its performance at low elevation angles.

Low Angle of Radiation

Long range HF communications require at least a decent radiation pattern at low angles. The histogram in Figure 3 shows the elevation angles at which West Coast openings to the Far East are most likely to occur for the case of 7 MHz. For this propagation path, all openings occur at elevation angles of 20 degrees or below. Similar elevation angle requirements apply for almost all overseas DX openings on 40 meters, whether for Europe, Africa or the South Pacific.

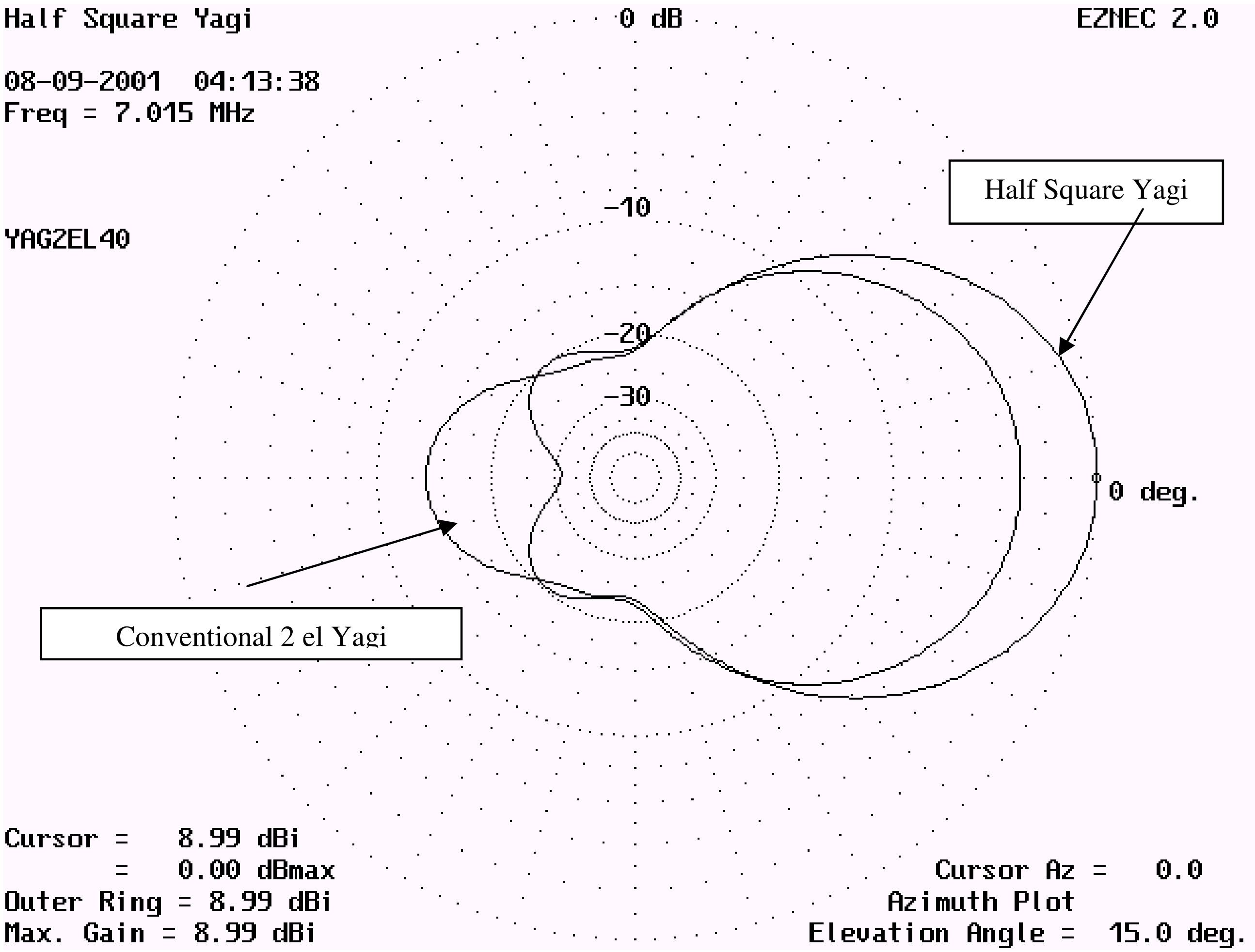

Figure 2. A comparison of the azimuth pattern of the half square yagi with a traditional two element horizontal yagi at the same 45 foot height.

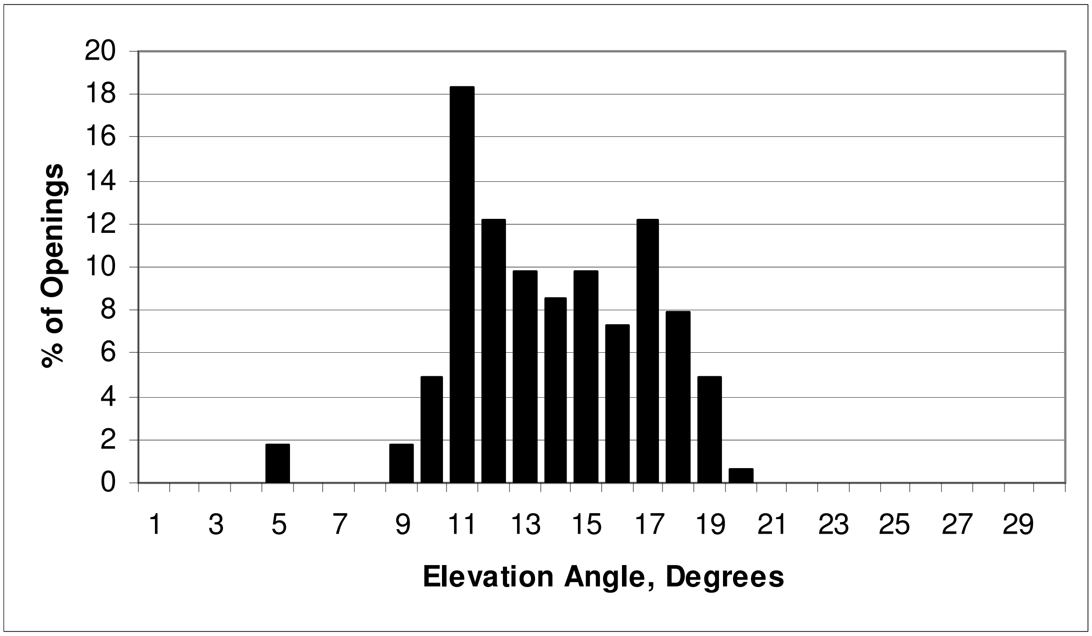

Figure 3. Percentage of all 40-meter openings from the West Coast to the Far East versus elevation angles. Note that most openings occur between 10- and 20-degrees above the horizon. Similar elevation requirements exist for most overseas openings. (Derived from data in the ARRL Antenna Book, 17^{th} edition.)

This low elevation angle requirement presents a major challenge for horizontally polarized antennas. A conventional dipole at 7 MHz would need to be 100 feet high in order for the center of its main beam to approach a 20 degree elevation angle. A two element conventional yagi on 40 meters would likewise need to be up more than 90 feet. An additional problem for horizontally polarized antennas less than $\lambda/2$ above the ground (roughly 65 feet for 7 MHz) is that they have strong response to incoming signals arriving at high elevation angles. This means that the signal strengths of local and regional stations will be enhanced at the expense of the weaker, lower angle DX signals.

Figure 4 compares the elevation pattern for the half square yagi with that of a conventional two element monoband yagi at the same 45 foot height. The main beam of the half square yagi is centered at an elevation angle of 15 degrees with a significant portion of its main lobe extending down to 10 degrees. Compared to a conventional monoband yagi at this height, the half square yagi provides 2 to 7 dB of signal improvement at elevation angles between 10 and 20 degrees. A full-sized conventional monobander would need to be up 75 feet to match the half square yagi's forward gain at 15 degrees, and would need to be up 125 feet in order for its main beam to be centered at this elevation angle. (And of course commercial yagis with lossy traps can introduce several additional dB of loss.) An added advantage of the half square yagi's strong performance at low elevation angles is that in addition to enhancing weak low angle signals from overseas, it effectively suppresses stateside signals arriving at higher elevation angles.

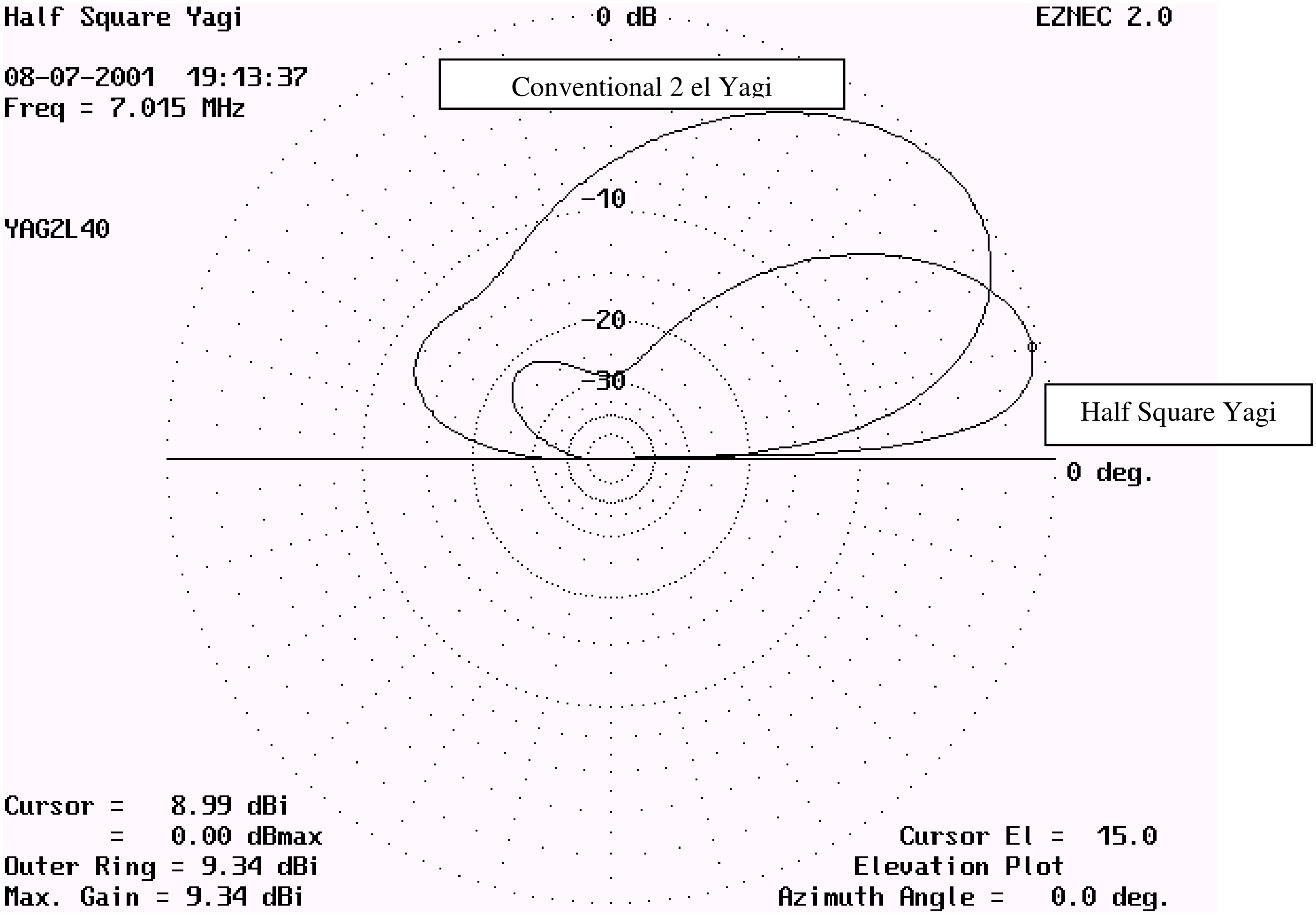

Figure 4. A comparison of the elevation patterns of a 2 element conventional yagi at 45 feet with a half square yagi mounted with the horizontal wires at the same 45 foot height.

The NEC antenna model used for these plots assumes an “average” ground with 5 mS/m conductivity and a dielectric constant of 13. As with all vertically polarized antennas, the effective radiation angle for the half square yagi will be lower at those locations where soil conductivity in the ground reflection zone is good, such as many portions of the South and lower Midwest. And of course, a saltwater marsh or beach front location is ideal.

The half square presents an input impedance of 49 ohms and an SWR of about 1.1:1 at resonance. If tuned for the center of the 40 meters the SWR remains below 2:1 over the entire 300 kHz band. Likewise, its forward gain remains within 1 dB of maximum over a 200 kHz bandwidth.

Before constructing this antenna, however, it is important that you decide whether it will primarily be for phone, CW / digital operation.   This is because the front-to-rear ratio degrades rapidly at frequency ranges greater than 50 kHz from resonance. Figure 5 summarizes the specific dimensions for operation in the DX portion of the CW subband – i.e. 7.000 – 7.030 MHz. Figures 6 and 7 show the gain and front-to-back ratio performance curves across the 40 meter band for this CW design. If the antenna is optimized for the bottom of the CW portion of the band, the pattern deteriorates at 7.3 MHz to a front-to-back ratio of XX with a drop in forward gain of 2.4 dB. As a result, this antenna is best designed for optimum performance in a single subband.

(see attached power point file)

Figure 5. Design details for operation centered near the bottom of the 40 meter CW subband and assumes 14 gauge bare copper wire. Note: the dimensions shown here will decrease approximately 2 to 3 percent if plastic-coated wire is used.

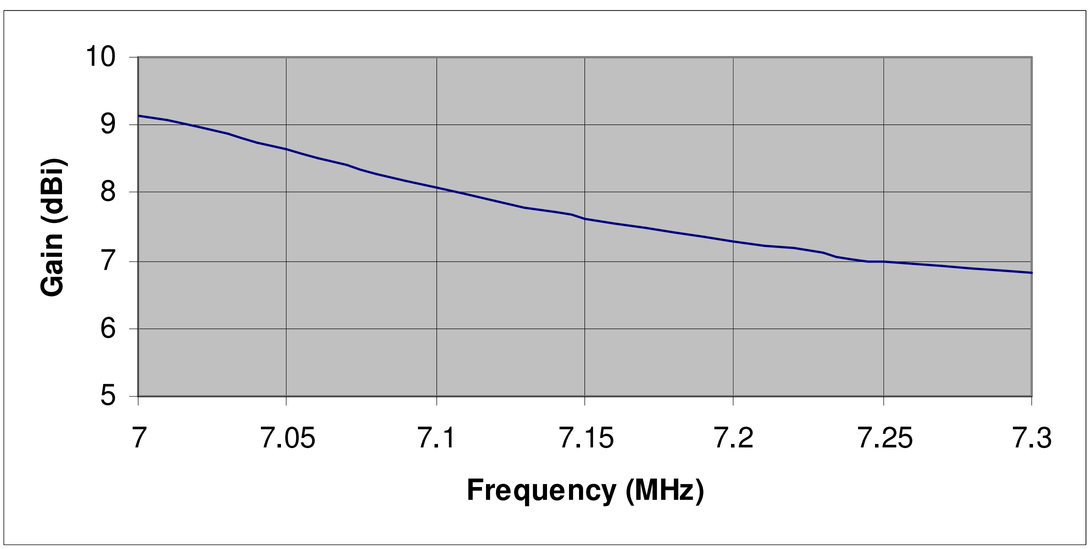

Figure 6. Gain as a function of frequency for the half square yagi optimized for the DX portion of the 40 meter CW subband.

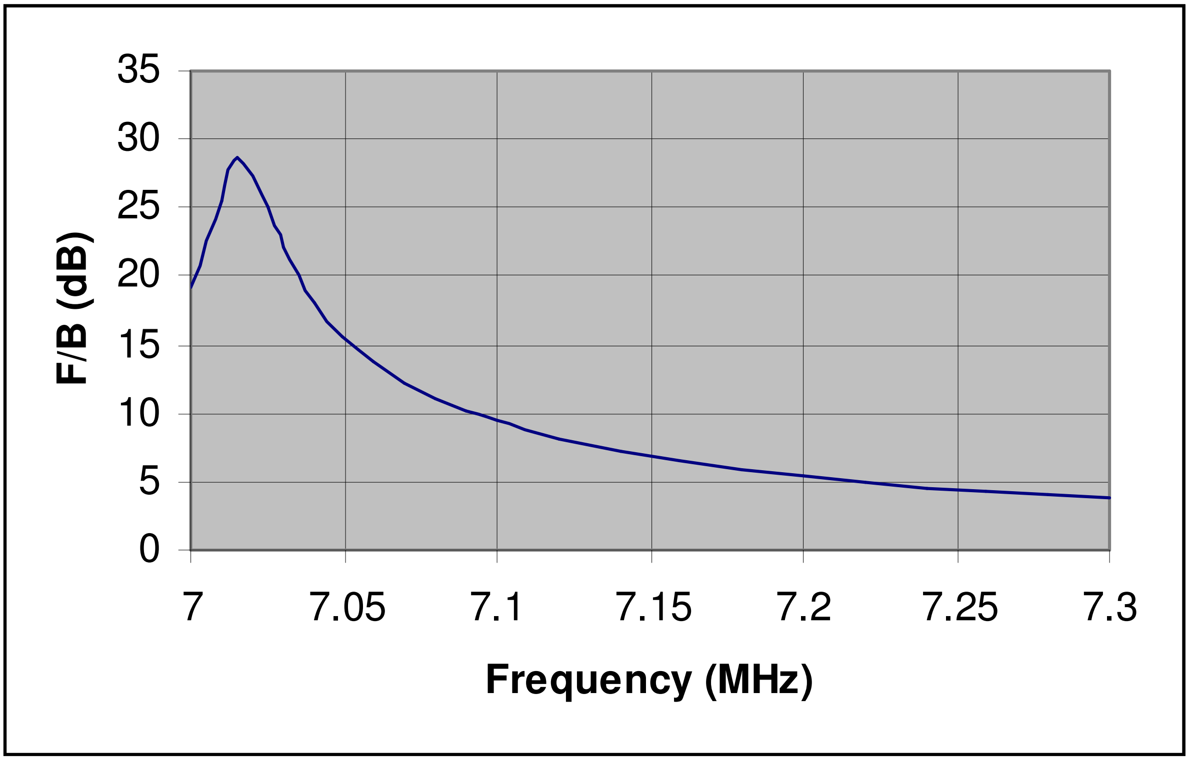

Figure 7. Front-to-back ratio versus frequency for the half square yagi optimized for the DX portion of the 40 meter CW subband.

Be sure to water-proof the coax at the antenna's feedpoint to prevent moisture intrusion. As much as possible, route the coax away from the driven element along one of the support ropes so that the feedline does not disturb the beam's pattern. In order to minimize surface currents on the outside of the coax that might degrade the antenna's pattern, use a 1:1 balun at the feedpoint by winding the first 20 feet of feedline into a coil. If you don't want to bother with a coil of coax at the feedpoint, a ferrite-bead shield-current choke is another good choice.

An alternative feed method to the corner-fed current method described above is to voltage feed the base of one of the vertical wires. Details of this feed method can be found in the ARRL Antenna Book. Unfortunately, voltage feeding a half square antenna reduces the gain and distorts the antenna's pattern away from the resonant frequency to a much greater extent than the current-fed method described here. This is because since the open end of the driven element is constrained to be a voltage maximum, the feed point (for the voltage-fed case) becomes less of a voltage point and more of a current one. This degrades the radiation pattern more rapidly than with the current-fed method since off-resonance current distribution asymmetry is much less when the antenna is corner-fed[vi].

Because the free ends of the antenna are high impedance points, very high voltages can develop even when operating at relatively low power levels. As a result, it is important to install the antenna high enough so the ends are above easy reach. And since the E field is strongest near high voltage points, keeping the ends at least 5 to 10 feet high significantly reduces E field-induced ground losses.

Tune-up procedure

Nearby structures, as well as differences in ground characteristics and antenna height, can all cause the optimized dimensions to differ from those listed in Figure 5. Be especially careful about keeping other 40 meter antennas (dipoles, verticals, etc) well away from the half square yagi's near field. When I initially installed this antenna, I neglected to dismantle a commercial HF trap vertical that was located in the beam's vicinity. During the half square yagi's tune-up process it became apparent that the feedpoint impedance was noticeably different from the predicted 49 ohms (implying that the beam's pattern was probably degraded as well.) Removal of the trap vertical from the local area brought the half square yagi's impedance close to the predicted level and probably improved the beam's pattern significantly.

There is merit in making all the initial dimensions a few inches longer than Figure 5 calls for, so that the antenna can be easily "pruned" for optimum performance. Ideally, the best tune-up approach involves alternately trimming the bottom ends of the driven element to resonance and adjusting the ends of the reflector for optimum rear cancellation by way of a calibrated field strength meter. A "quick and dirty" approach that I found to be reasonably effective is to hoist the antenna, trim the two ends of the driven element for resonance (pruning each end by the same amount), and then trim the ends of the reflector by the same amount as the driven element.

On the Air Performance

I originally constructed this antenna in 1996 and have been very impressed with its performance. This is in spite of the fact that my antenna's location was physically near two other antenna masts and my house. I found it did an excellent job of reducing noise and interfering signals from unwanted directions and gave me an ample signal to the west where it was pointed. During the first month after installation, I made 90 early morning Far East contacts on 40 meters and had a ball doing it!

Conclusion

The half square yagi is a simple, low-cost, and highly effective antenna for low band DXing that does an excellent job of suppressing high angle local/regional signals and interferers off the sides and rear. In addition, it is easy to feed and install. The upper suppport points are all at low impedance which makes directly running these portions of the antenna through trees an option.

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[i] Woodrow Smith, W6BCX, "Bet My Money On a Bobtail Beam," *CQ*, Mar 1948, pp 21-23, 92.
[ii] Ben Vester, K3BC, "The Half square," *QST*, Mar 1974, pp 11-14.
[iii] *The ARRL Antenna Book*, 17th edition (ARRL: Newington), Chapter 8, p 8-6.
[iv] Paul Del Negro, N2PD, "A Half square Array for 40 Meters," QST, Jan 1998, pp 46-49.
[v] "Feedback on 'A Half square Array for 40 Meters'", QST, Feb 1998, pg 72.
[vi] Rudy Severns, N6LF, "Using the Half-Square Antenna for Low-Band DXing", The ARRL Antenna Compendium, Vol 5, pp 35-42 (ARRL: Newington, 1996) Order No. 5625. See Note 2 for ordering information.
[vii] The physical separation distance between the driven element and reflector in the half square yagi is about 45% less (i.e. 20 feet) than with the quarter wavelength spacing (35 feet 9 inches) of the actively-phased approach.
[viii] For a variation of the half square yagi designed for VHF 2 meter operation, refer to L.B. Cebik, W4RNL, "True Vertical Beams for 2 Meters", Communications Quarterly, Summer 1999, pp. 25-34.
[ixix] The yagi design relies on parasitic coupling between the driven element and the parasitic elements with a significant proportion of the driven element's current being coupled to the reflector and director elements. But when a horizontally polarized yagi is lowered to between about $\lambda/4$ to $\lambda/2$ above ground level, the reverse polarity of the ground image of the driven element begins to couple heavily with both the driven element and the parasitic element. As a result, the desired parasitic currents can become difficult to achieve

at any useful spacing. This effect is substantially less when vertical polarization is used, since the vertically-oriented image of the driven element doesn't exhibit a reversed polarity the way a horizontally-oriented image would.

[x] *The ARRL Antenna Book*, 18th edition (ARRL: Newington), Chapter 3. Order No. 6133. ARRL Publications are available from your local ARRL book dealer or directly from ARRL. Mail orders to Pub Sales Dept, ARRL, 225 Main St. Newington, CT 06111-1494.

Buy and Sell

For Sale: LMR-400-75, used for antenna testing, no connectors, 196ft for $100 and 250ft for $125. George N6NKT, see QRZ.com for email address.

Send Buy and Sell information to:
het_editor at wvara.org

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See You At The Meeting!