IRCA Technical Column

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Testing Two "KAZ" Squashed Delta Antennas

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I was really excited when veteran MW DXer Neil Kazaross began using the EZNEC antenna modeling software to optimize various large loop antennas for MW DX use. As far as I know, most of the previous work with K9AYs, etc, has been optimized for the 160 meter radio amateur band.

The first design that Neil actually constructed was what he has been calling a "squashed loop." This design, with a 1 to 4 "aspect ratio," is one that the modeling software shows to reject low arrival angle signals from the backside even better than the classic equilateral pennant/delta. The dimensions of the loop were 10' high by 40' long. For convenience, I have come to refer to this antenna as a "KAZ-10x40" or just the KAZ.

I've operated a four-loop K9AY antenna for two years now, both in my winter home in Oklahoma and at my summer cottage on Orcas Island north of Seattle. I'm interested in finding an even better antenna than the K9AY for use in both locations. In Oklahoma, I DX Mexican MW stations and the primary concern is the rejection of unwanted co-channel signals. Gain is not so important, since signal levels, in general, are quite high during the prime DXing hours. In the Pacific NW, my main interest is DXing Trans-Pacific MW signals. There, gain is king, since the majority of those very weak signals are almost alone in between the 10 kHz. channels of the North American stations and since Trans-Pacific conditions are often extraordinarily quiet.

I've tested quite a few antennas over the years, often with well-known Lowfer, Bill Bowers. He has a wide array of laboratory-grade equipment. We've both pretty well concluded that it is impossible to measure the actual F/B ratio of an antenna on MW. We usually work in the very middle of the day to eliminate as much ionospheric skip as possible, but we still have great difficulty finding stations that are totally alone on their channel to use in the tests. Even when there seems to be no other station "in the null" of the target, the antenna is still likely receiving several weak carriers, thus partly filling in the null and reducing the measured F/B quite significantly over the absolute value determined by the antenna configuration. We've found that doing direct A/B comparison tests between two or more antennas simultaneously tends to give us a more useful idea of which antenna is performing best. Since I my semi-permanent K9AY is in a pasture with plenty of room to spare, I decided to try both methods of testing.

My K9AY is a classic equilateral delta, 28 feet on a side, with the lower wire about 1.5 feet above ground. My KAZ-10x40 was mounted on a piece of ABS plastic pipe, with the apex at 11 feet and the lower (40 foot) wire at about 1 foot above ground. The KAZ-10x40 was constructed of multi-strand 12 ga. wire and terminated with 885 ohms of resistance. The impedance transformer was hand wound on an Amidon FT-114-43 (10 turns and 44 turns). The two terminations were attached to the antenna with banana plugs so that the ends of the KAZ could be swapped without actually moving the loop itself. The coax antenna leads enter my shack where I can switch instantaneously between the K9AY and the KAZ. Signal strengths were measured with my Ten Tec 340 that has an S-meter which is calibrated in -dBM as well as S-units.

For initial testing, I selected 10 stations in located in Southwest Oklahoma or in/near Northeast Oklahoma. These stations were on both ends of the dial and were generally in a direct line diagonally across the state with me in the middle. The antennas pointed right down the diagonal line.

TESTING FRONT TO BACK RATIOS & RELATIVE GAIN: K9AY vs. KAZ

Unfortunately, five of the ten stations had a fairly strong co-channel when the primary station was nulled: GREAT for DXing, but impossible for F/B measurement. Four of the remaining five stations were running less than 20 dB above the noise floor when peaked. When nulled, they went into noise, of course, but that doesn't really indicate an accurate F/B ratio. I was able to do a reasonably accurate F/B ratio only on KGGF, 690 in Coffeyville, KS. The K9AY provided a 20 dB ratio and the KAZ-10x40 did 23 dB. I trust the validity, though not the level, of this reading. KGGF is exactly in line with the antenna, to my NE, and puts an S-9 plus signal here via a directional pattern. It is important note, though, that there is a 250 w. ND station directly off the SW end of the antenna (KPET in Lamesa, TX). It is very likely that this station, though not audible during my F/B measurement on 690 KGGF, was probably acting to "fill in the null" during the test. How much did it contribute? Who knows, though 8 to 10 dB does sound reasonable to me.

During the Front-to-Back testing process, I was able to record accurate "relative gain" figures on eight of the ten stations, while they were directly off the front of the antennas. My figures varied between 10 and 15 dB more gain for the (unamplified) K9AY over the (unamplified) KAZ-10x40. Also refer to more formal gain measurements later in this article.

"IN USE" COMPARISON TESTING: K9AY vs. KAZ

When comparing the two antennas during prime time DX hours in the evening and early morning, things got really interesting. The signal levels were high enough that it was impossible to tell the difference between the native gain of the two antennas "by ear," I had to look at the S-Meter. In about 80 to 90 percent of the cases, the content and quality of the two signals was identical, as well. In that other 15 percent or so, the KAZ out-performed the K9AY!

For instance:

1510 kHz. has WLAC, Nashville and XEQI, Monterrey at about equal distance from me. Looking toward Monterrey, the KAZ must have less side-lobe than the K9AY, because the XEQI signal was always clearer on the KAZ, even when I attenuated the K9AY by 10 dB to equalize the gain of the two antennas.

700 kHz. has nearly unnullable WLW on it. Pointed southwest, mostly away from Cincinnati, The K9AY gave me a signal of -80 dBM, while the KAZ provided a -103 dBM, much weaker. If you factor in the 10 dB or so of difference in native gain of the two antennas, it appears that, in this instance, the KAZ nulled WLW by an additional 13 dB! What's more, for the first time ever, I could actually listen to a station co-channel with WLW! While writing the first half of this article, I enjoyed listening to XEDG, 700 kHz. Radio Romantica in Hidalgo del Parral, Chih. With the KAZ, Radio Romantica was in the clear about 50% of the time and in a jumble the rest. The K9AY can manage to "hear" the Mexican about 2/3 of the time, but always rather far

beneath WLW. One of the nicest things about the KAZ that both Kazaross and I have noticed is the ease of shifting its direction. The next morning, I took 5 minutes and shifted the KAZ 25 degrees more toward east-west to get WLW in the exact rear null and now I often listen to Radio Romantica totally undisturbed!

Some examples of equal performance of the K9AY vs. KAZ:

580 kHz. Both antennas eliminated semi-local WIBW in Topeka, KS and revealed XEMU, Piedras Negras running at "about S-8." GREAT WORK!

780 kHz. WGN puts in an above S-9 signal here at night. With both antennas turned to the southwest, XEMF, Montclova, Coah. ran "about S-6" with WGN about 95% gone.

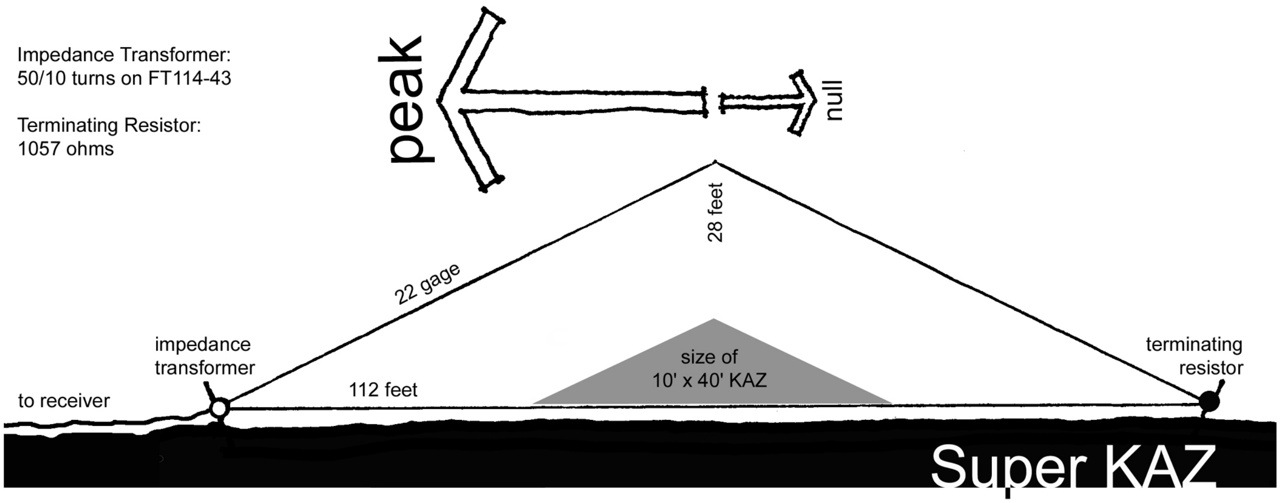
Both of the later two tests were done with the S-meter covered…. I could tell no difference "by ear" between the two antennas and just estimated the signal strength.

The "Super KAZ"

After reading a draft of the first half of this article, antenna guru K6SE cautioned that gain is not really an issue in a receiving antenna since actually hearing the signal was dependant upon the signal-to-noise ratio rather than the absolute gain of the antenna. There is an old truism which states that "if you can hear the basic band noise well, you'll hear any signal peaking above that band noise even better. Of course, that is true, as far as it goes. However, it's been my experience that there are more occasions than people realize where the absolute gain of a receiving antenna **is** the limiting factor. Mostly, these occasions may arise when you are listening to a very quiet band, with a very quiet receiver. Since I'm using a new Ten Tec 340 and since I'm fortunate enough to live away from virtually all man-made noise (hey, itsa big cow pasture!) I was very interested in finding out if the 40' KAZ was "gain-limited" in any meaningful way.

About a week ago, I built "Super KAZ," a 28'x112' version of KAZ, using 22 gage wire and one of the fine 10 meter telescoping fiberglass masts from Germany. Using the much smaller gage wire, Neil figured the impedance at about 1060 ohms. I ended up winding a new impedance transformer (50 turns vs 10 turns on a FT-114-43 Amidon toroid) and boosting the far-end resistor to 1057 ohms.

While testing the smaller KAZ at mid-day, I had noticed several rather weak signals coming from the southwest (the center of gain) seemingly all alone on their channels. Further, there were no strong signals on immediate adjacent channels and my daytime MW conditions are as near noise-free as it gets. So, this seemed a perfect opportunity to model the conditions that I R*E*A*L*L*Y care about: that marvelous 90 minutes, centered on dawn, when (on the Washington coast) the band noise often drops to near zero and the whole of East Asia opens up for MW DXing.



Gain Does Seem to Matter

Working about mid-day, I was able to find six stations at threshold audio levels on the 40' KAZ. Two were located at the low end of the band, two at the middle and two at the top. I put the KAZ adjacent to the Super KAZ on my antenna switch and began to compare. In every instance, the apparent signal-to-noise ratio was *significantly better* on the Super KAZ. In other words, the S-meter showed a much stronger signal on the Super KAZ….. as expected…. but, there was also a very significant improvement in the quality of the signal. All or almost all of the "band noise" left the signal on the Super KAZ. I rechecked all of my connections and thought about the whole thing for a while. Since the basic signal-to-noise ratio of an antenna is related to its sensitivity pattern and since the pattern (but not the gain) of the KAZ and the Super KAZ should be identical, the 40' KAZ must be "gain limited" under the specific conditions tested. In other words, what I was hearing on the 40' KAZ was **not** band noise, but rather the noise floor of my receiver! I added about 10 dB of amplification to the KAZ signal and attenuated the Super KAZ a like amount; this pretty well equalized the apparent gain of the two antennas. As expected, the KAZ signals remained much noisier than the same previously marginal signals when received with the Super KAZ.

Final Gain Comparisons

To complete the study, I ran final gain comparisons between all three antennas, again at about mid-day. The K9AY is listed both first and last in the following chart:

Daytime Gain Comparisons
K9AY vs KAZ vs Super KAZ vs K9AY

Station	*K9AY*	*diff.*	*KAZ*	*diff.*	*Super KAZ*	*diff.*	*K9AY*
540 Monterrey	-93	11	-104	21	-83	10	-93

930 Okla. City	-57	14	-71	22	-49	8	-57
1050 Lawton	-92	20	-112	25	-87	5	-92
1320 Clinton	-97	13	-110	20	-90	7	-97
1460 El Reno	-84	17	-101	23	-78	6	-84
1520 Okla. City	-56	14	-70	21	-49	7	-56
MEAN		**14**		**22**		**7**	

K9AY is a 28' delta, KAZ is 10' x 40', Super KAZ is 28' x 112'

I also rechecked the front-to-back ratios of each KAZ antenna, again at high noon, again using KGGF, Coffeyville, KS, 690 kHz. as my target. This time the KAZ measured only 18 dB (it had previously measured 23) while the Super KAZ measured 23 dB of F/B. The differences in the two measurements of the 10x40 KAZ simply reinforce the vagaries of measuring F/B ratios on MW, even at high noon on a carefully selected station. I have noticed real differences in the day-to-day daytime propagation here at the solar peak. My guess is that the station in Lamesa, Texas was filling in more of the null as I noticed that XEWA on 540 was actually audible at good levels at mid-day, very unusual for my location. What the test did show, unequivocally, is that the Super KAZ had a F/B ratio at least as good and probably somewhat better than the KAZ, at least as I've constructed them.

The F/B ratios of these two KAZ designs ought to be identical, I think. Probably, too, the termination resistor of the smaller KAZ is not quite the correct value. Neil calculated the gain difference between the two versions of the KAZ at 17 dB, where I measured 23 dB. That, too, argues that my small KAZ is not quite operating at the optimum.

CLOSING REMARKS

Although I intend to run many more tests of the Super KAZ and a mid-sized KAZ in the Pacific Northwest this summer, I think I've come to at least a few useful findings:

1) The useable directivity of the 40 foot KAZ is at least as good and probably just a bit better than my classic K9AY at both the top and bottom of the band. That's great news, since the KAZ is so much smaller/cheaper. Neil designed the 40 footer as small as he dared, hoping to develop an antenna that could be erected in an urban back yard, a rooftop or even in a large attic.

2) The classic K9AY outgains the 40 foot KAZ by just about 12 to 14 dB. I measured this before I read the upload where Andy Ikin was quoted as saying that an increase in cross-sectional area of a loop by double gets ya about 12 dB of gain. The area of the KAZ-10x40 is 200 sq.ft. the area of the classic K9AY is 350 sq. ft. Later, Kaz calculated the difference between my two antennas and got 10 dB. How 'bout that... It pleases me that my measurements and science come close to agreement... adds confidence about my process and about the prediction models.

3) Given the relatively high signal levels at night, the 12 to 14 dB difference in gain between the K9AY and the smaller KAZ was ALMOST NEVER perceivable in the audio. When I covered the S-meter for a while, I simply couldn't tell the difference between the two antennas, most of the time. Occasionally, as discussed above, the KAZ was actually was superior - due to reduced backside slop. It also pleases me that this very small KAZ, a real "urban DXer's" antenna, can perform on a par with the K9AY for almost all real-world DX situations.

4) H*O*W*E*V*E*R..................................... In the Pacific Northwest, under those marvelous dawn conditions on medium wave, I need all the gain that I can get. The K9AY is pretty non-competitive with Beverages out there without its 10 to 13 dB of switchable amplification... and I'd really like more native gain from the KAZ... so, out there, I'll darn sure be trying the Super KAZ as a potential Beverage beater!

Obviously, a good deal more work needs to be done to optimize both the K9AY and the KAZ for MW DXing in various parts of the US and abroad. A number of questions come to mind:

1) What is the smallest KAZ that will not be "gain-limited" even at the bottom of the broadcast band? Is there any theoretical work available on this???
2) What happens to a K9AY when one goes to the full 1 to 4 KAZ aspect ratio? The one undeniable advantage of the K9AY configuration is the ease of loop switching arrangements.
3) Will the added gain plus the excellent front-to-back ratio allow the 120 foot Super KAZ to compete with Beverages on the West Coast at dawn? Truly, I suspect not, though the F/B may really help us in DXing the hard-to-hear Hawaiian channels and the Trans-Pacific stations where the 9 kHz. per channel and the 10 kHz. per channel rhythms coincide.
4) I wonder what a phased array of two KAZs of about 15 x 60 and spaced about 250 feet apart would look like. I can just fit that in my Okie cow pasture………. hummmm.
5) Speaking of phased arrays, I just purchased one of Gerry Thomas' new Quantum Phasers and it has been love at first sight. I can routinely and easily lay at least 45 dB of null on local pests during the day. Night operation of any phasing unit is much more of an art form, of course. While I was testing the F/B of the two KAZ designs against KGGF, I phased the two of them against each other while they were pointed directly away from the station. The total F/B of the system was 55 dB! That's taking an S-9 + 20 dB signal just about down to the noise floor and in a cardioid pattern at that.

Neil Kazaross' work modifying the K9SE delta is certainly pointing the way to some VERY useful antennas for us all and has led to a lot of fun for me. BRAVO Neil!

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Andy Ikin of Wellbrook Communications (sales@wellbrook.uk.com), submitted his own test of the KAZ antenna to the Flag and Pennant Antennas group (info at http://www.egroups.com/group/FlagandPennantAntennas), and his comments are reproduced with his permission:

Approximately two weeks ago I decided to give the KAZ Delta loop a try to see if there was any improvement over my existing K9AY.

The KAZ Delta loop E-W (10 foot by 40 foot) was set up near to my K9AY E-W loop. The base of the KAZ was 1 foot off the ground, with one end connected to 20:1 impedance matching transformer, the other end was connected with a Perkins/Elmer VLTC4 Vactrol to provide remote controlled termination. Testing was conducted between 10 am and 3pm local time.

On LW, both Allouis 162 kHz and Europe No 1 183kHz yielded 17.5dB front to back ratio (F/B), whilst RTL 234kHz and Kalundborg 243kHz provided 12.5 dB F/B.

Medium wave F/B varied from 17.5dB for Paris 864kHz and Belgium 621/540kHz to 30dB for Lille 1377kHz and Flevoland 1008kHz (Flevoland 747kHz F/B was 20dB). 13dB of pre-amplification at the receiver was used to raise the signal above the receiver noise floor so that the F/B could be measured. Without pre-amplification, the low gain degraded the reception quality of a significant number of weaker stations. The average F/B for LW was 15dB and MW was 23dB. The use of a common mode feeder isolation choke next to the matching transformer made no difference to the F/B.

Comparing the above without pre-amplification to Gary Breed's K9AY (un-amplified) with remote controlled termination. The K9AY provided about 3 dB higher F/B for RTL and Kalundborg and the same F/B for Allouis and Europe No 1. The K9AY gain was typically 10dB higher on LW and 15dB higher on MW. On MW, using the K9AY the F/B varied from 20 to 40dB. The average F/B for LW was 15.8dB and MW was 30dB.

I also tried the K9AY using a KAZ size loop. On LW the F/B was the same as the ("regular") K9AY. For MW the F/B was typically 7db lower. At 19:00 hours using the K9AY I was able to null Flevoland (400kW) to provide useable reception of Cadiz (10kW). The K9AY (KAZ) null was not deep enough to provide a useable signal from Cadiz. The gain difference between the two K9AYs was about +7dB in favour of the Gary Breed K9AY. However, I don't see the performance difference between the two K9AYs as a problem, but something to be expected from two loop shapes.

My real concern was the poor F/B performance of the KAZ on MW, so was I doing something wrong or was some other factor affecting the performance? I did not compare the KAZ to another Pennant. So it would be unfair to say that the problem was just with the KAZ.

My first thoughts were just to dismiss this exercise as another failure. However, I decided to do some more experimentation; first was to increase the antenna gain by placing an amplifier directly to the loop. This would provide reverse isolation of the feeder to the antenna and so prevent any feeder induced signal degrading the F/B. The Amplifier I used was a DATONG AD270 Active Dipole Head Unit. This resulted in increasing the average LW F/B to 19dB and the MW F/B to 27dB. The down side to using the DATONG AD270 was too much gain on LW resulting in RX overload with Broadcast Stations. Next, I had the idea of using an amplifier/Vactrol combination at each end of the antenna to provide a remote control of the antenna direction together with remote termination control and feeder isolation. Unfortunately, I didn't have another AD 270, so I built two Hi impedance input Amplifiers using VMOSFETS in a differential/push-pull configuration (antenna connects directly to the FET gates via coupling caps). Using Hi impedance input Amplifiers allows for the Amplifier to shunt the Vactrol with only a minor reduction in the F/B. Each amplifier feeder and the Vactrol control line was brought back to a Control box next to the Rx. The antenna direction was achieved by simply switching one of the Amplifiers to the Rx and controlling the Vactrol at the opposite end of the antenna. This Reversible KAZ provided an average LW F/B of 18dB and the MW F/B of 28dB. Unfortunately, I didn't slug the HF gain of the VMOS amplifier, thus I did experience some intermod on MW. However, I considered that this antenna design was a success, as I had integrated four improvements to KAZ/Flag/Pennant; 20dB gain, Remote Reversibility, Remote Termination and Reverse Feeder Isolation.

Later, I abandoned the VMOS FET Antenna Amplifier in favour of a Bipolar design (a 20dB gain version used in some Wellbrook K9AYs). This Amplifier was used with a 20:1 input transformer and a DPDT relay to switch the antenna to either the Vactrol or the amplifier. With no power (12volts via the feeder) applied to the Amplifier, the Vactrol would terminate the antenna. Applying power to the Amplifier, the relay is energised to isolated Vactrol and connects the Amplifier to the antenna.

The remote Vactrol termination is controlled via a separate single wire from the Control Box, the control voltage return path is via the feeder screen. Thus, by just selecting (powering up) the amplifier, remote beam reversal is achieved. This amplifier configuration provided the same performance to the VMOS version, with an average LW F/B of 18dB and the MW F/B of 28dB without any intermod problems. This Antenna amplifier system could be expanded to several antennas with the Vactrol control line being daisy changed to the amplifiers.

A single pole multi-way switch in the Control Box is just required to select the required antenna amplifier. Alternatively, a relay box could be used at the 'Antenna Farm' to reduce the number of feeder cables coming back to the antenna control box.

An interesting feature of this antenna design is the possibility of its use with the EWE antenna and the Delta and Diamond variants of the Pennant/Flag.

To summarise;

20dB gain, Remote Reversibility, Remote Termination and Reverse feeder isolation is achievable in one design.

Although this antenna configuration is more complicated than the K9AY, I am pleased that it achieve the same performance.

Finally, I think that one issue with the Flag/Pennant antenna needs further investigation: Is reverse isolation of the feeder a key factor in achieving a good F/B ? (a 20:1 transformer does not provide any reverse isolation, it only reduces capacitive coupling). Or is simply increasing the gain of the antenna before the feeder improving the F/B? If either is the case, then placing the amplifier next to or very near to the antenna may be a necessary design feature!

(ed. note) Mark Connelly has compared a Pennant antenna with a KAZ antenna, and the results can be found at the following address:
http://members.aol.com/DXerCapeCod/pennant_v_kaz.htm

Mark’s site, http://www.qsl.net/wa1ion/index.html has a number of good articles and links to articles of interest to the technically inclined MW DXer.