ADDITIONAL FIELD INFORMATION ON THE DOUBLE-DELTA (D-KAZ) ANTENNA

Revised 052615

(This supplants and updates early conclusions and observations)

Wherein we find:

- The changes and updates 050815
- About the Double-Delta/"D-Kaz" Antenna
- Measurement conventions
- Performance consistency: Real-world observations
- Our experiences with the Desert Broadside
- Pattern-reversal
- Roll your own D-Kaz: Ideas about deployment
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Mark Durenberger
DX-ing near N 45 48 56 W 94 34 46 AND at N39 09 W 109 15(Utah desert)

UPDATE: It has been nearly a year since the original posting regarding our success with the D-Kaz antennas. In addition to confirming measurement results at the original QTH during the summer/fall of 2014, we recently embarked on another Desert DXPedition (late-April 2015) whose primary focus was to learn how the D-Kaz performs in an utterly different environment (very dry ground conditions as opposed to the previous "normal" moisture conditions in Minnesota). Here we add new insights, confirm some of the our early conclusions and describe our experiences with a "Broadside D-Kaz."

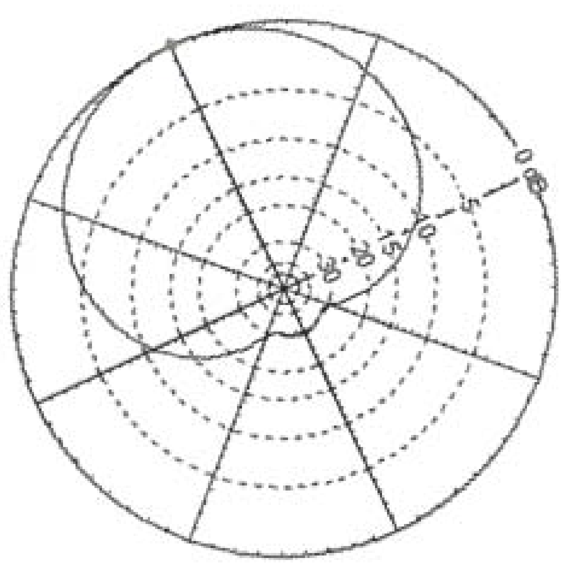
A few years ago we met the Double-Delta antenna, as modified by the brilliant DX-er Neil Kazaross with input from the late John Bryant, to become the "D-Kaz" antenna. Kaz came up with this approach as the result of his newly-acquired passion for EZNEC modeling. ("EZNEC" is pattern-prediction software that allows one to analyze the expected performance of an antenna, based on proposed physical and electrical parameters.)

Several DX-ers are having really good luck with the D-Kaz. Our work for the DX Audio Service (DXAS) involves vacuuming targeted areas for MW signals. We found the D-Kaz to be exemplary for our specific purposes.

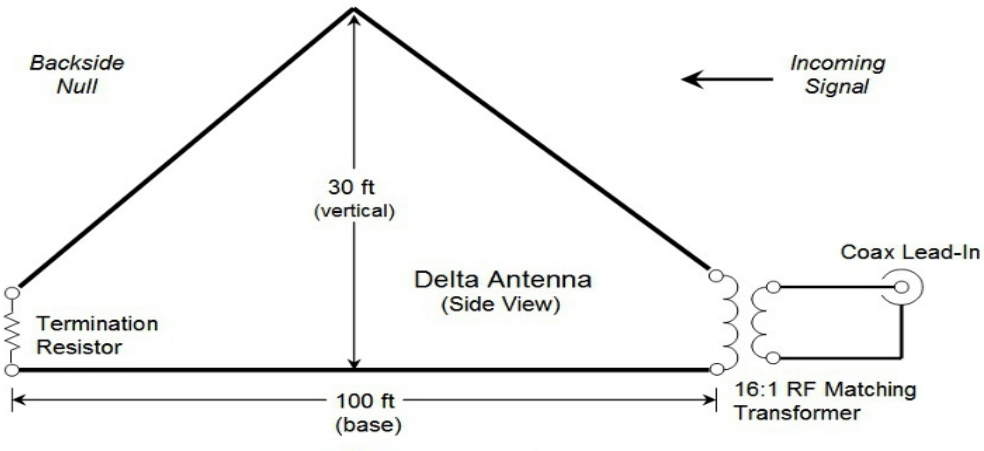
Kaz's models and subsequent real-world observation demonstrate that front-to-back ("F/B") nulling can approach and exceed 40 dB rear-signal rejection on much of the MW broadcast band. That's awesome.

In June 2014 we carved out a few days to measure D-Kaz MW performance. Results were posted on several DX reflectors. Information from the desert experience is now added, in context.

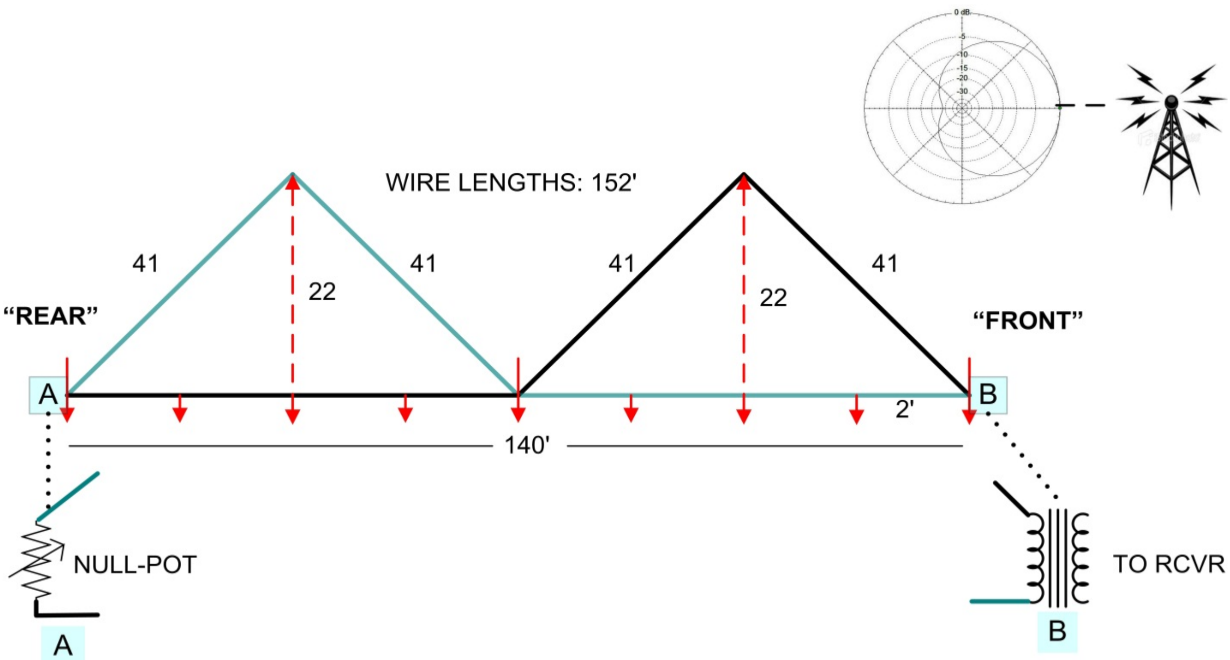
If you're new to the D-Kaz, read on…about a small, *reversible* wire antenna that can deliver this pattern:



Here’s a basic Delta configuration that favors signals from one direction and rejects them from the other:



The **D-Kaz antenna** is a Double-Delta variant, as seen below. Like many other ‘Flag-variety’ antennas the self-impedance of the D-Kaz at Medium-Wave is around 900 ohms, as seen at the two ends. The “D-Kaz” is realized by stacking and “interleaving” two of these Deltas:



Each of the two D-Kaz wires composes two-thirds of a triangle…and then continues as the base of the other Delta. Crossfire phasing creates a 180-degree phase shift, so the resultant pattern is similar to two loops in series fed with close to a 180-degree phase difference. Here’s an interesting way of contemplating this antenna…from the mind of Jim Snowbarger; a DX-er blind from birth:

“If you lay out a rectangle of wire, short vertical sides, and long horizontal sides, and just pick up the right hand side of the rectangle and flip it over, trading top and bottom ends of the right hand vertical edge, the rectangle is now twisted, and the long horizontal members cross, you can bend the wires as needed, even giving up the 90 degree corners, to form it into this dual triangle shape, where the wire that forms the base of one triangle, extends to become the side of the adjacent triangle.

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“It was that mental exercise that pointed out to me that these two loops are out of phase. And, they have a certain amount of physical distance. So, there is phase delay due to that (distance) as well. The null-pot balances the effects on that separation, to get cancellation.”

It's the simplicity of the practical arrangement that's appealing.

CONVENTIONS: *"F/B" (Front/Back) signal ratios* are derived from a reduction of signals to the "rear" by nulling those signals (see above diagram). This is accomplished by the wire routing and furthered by adjusting the null pot to compensate for the physical arrangement.

"Null" as used in this document is a 'minima,' not a complete elimination of unwanted signals. Depth of the null is a figure of merit of the antenna. It allows us to define "F/B ratio."

"F/B" ratio is the difference in dB between a signal level measured when the antenna's "front" is looking at a station, and that signal level recorded when the antenna's "back" is looking at the same station, after *nulling*.

This may seem cumbersome to realize, but when you add the "reversing" capability of the array as described below, you can get to these ratios by simply flipping a switch.

Because of this reversing capability we put "Front" and "Rear" (or "Back") in quotes. "Front" and "Rear" are abstractions, though by convention the "front" side is the end facing the desired signals and the "rear" or "back" faces the undesired signal. Throughout the hobby, these terms are used somewhat interchangeably but we like using "F/B."

"BEST F/B": This conclusive D-Kaz performance variable reflects how well the resistor on the back end matches the lumped impedance at the front (the input to the receiver). *The best operation of the antenna is found when the impedances approach equality, across a couple of octaves of Medium-Wave frequencies.*

That match may be found only in a perfect world and in our pragmatic environment, we find that it maybe doesn't matter so much. We deal in various physical environments with a real-world wire array that has its own lumped impedances; some of which we can't control. It's not a perfect antenna. But it's pretty good!

But experimenters strive for the best, and to approach that optimum we think that: 1) the null "R" might be shaped into *a network that mimicked the receiver input impedance* **AND/OR**: 2) the *receiver impedance might be shaped to look more like the null-pot's resistance.* This was going through our head as basic 'Bridge' theory.

If you don't need to adhere to the "99% rule," without too much futzing around you can make the D-Kaz deliver F/B ratios exceeding more than 30 dB And in our M-W DX world, 30 dB F/B is about as good as infinity…until they repeal sky-wave. We haven't seen our Beverages get to that sort of number very often and, while they *may* be more directive, some Bevs tend to put more side-lobes into the mix. Beverages may be more fun to some…but an elevated Beverage is harder to deploy than a D-Kaz and requires more geography.

D-KAZ ANTENNA SIZE: Experimenters are trying various antenna lengths. Neil Kazaross's EZNEC program correctly predicted that shorter versions (less than about 120 ft.) cause some degradation in low-end MW performance, while the longer versions (more than 160 ft.) don't produce good front-to-back nulling at the high end of the band. A good compromise length turns out to be **120 to 140 feet**. In these lengths, "it's a darn good antenna" as Nick Hall-Patch might say.

In our desert experience we confirmed our own original findings that 140 ft. x 22 ft. height is an aspect ratio that provides a good compromise.

USING THE D-KAZ—FINDING THE BEST F/B NULLS: Your approach to DX-ing with the D-Kaz might be to simply set the null resistance for the *deepest average null across the band*. You'll do that if you elect to simplify the system by using a fixed resistor as the null. But be sure to determine that average value through observation; don't guess. And yet: if you DO want to guess, you won't be far off with about 850 to 900 ohms.

On the other hand, if you're chasing specific frequencies…you might want to *re-adjust the null for each target*.

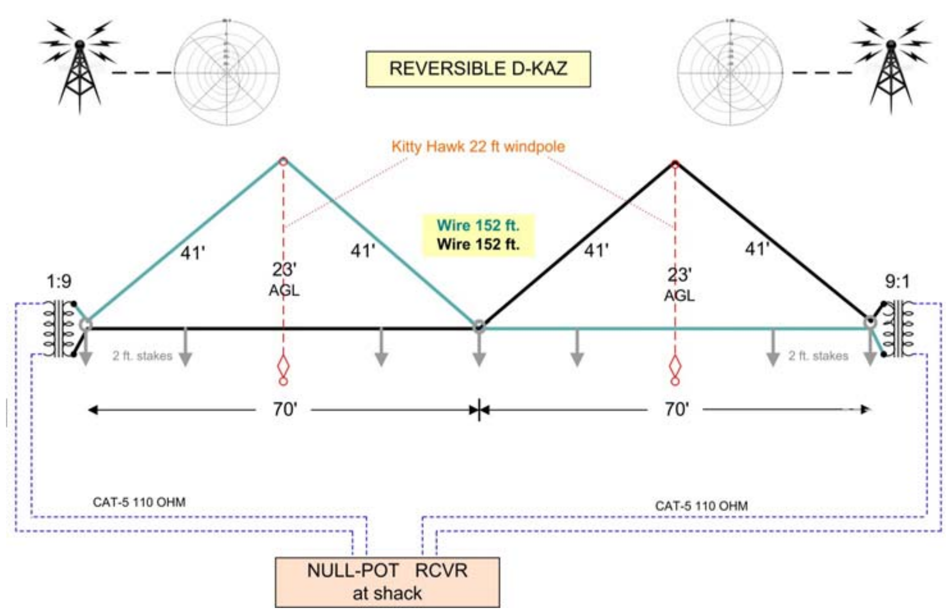
USING THE D-KAZ—THE MONITOR POINT: Where you work the antenna depends on your approach. Ideally, null-pot and receiver are side-by-side for convenience. You locate at the wire…or you 'extend' the ends to the shack for comfort and for convenience. There are practical differences in each approach.

For tightest performance you'll be using *a null-resistance connected directly to the wire*. (And you'll be recruiting another set of eyeballs if the receiver is at the other end.) With this arrangement, the only thing limiting excellent nulls may be the performance of the receive-side's *step-down balun*.

The next-best approach is to *extend the receiver feed from the receive-end of the D-Kaz, back to the null end,* which you'll do if you want direct observation of your nulling activity. (Make sure you route this extension well away from the antenna (so the extension will be a few dozen feet longer than the antenna itself.) This gets you direct receiver observation while you're adjusting a null-pot connected directly to the antenna.

If you like working out of the weather, you can extend both ends of the antenna to a 'remote' location…or, perhaps better, you can use a fixed null resistor of a value determined by observation, and extend only the receive-end transmission line to the "shack." *Extending the null-pot remotely* may work for short extensions, but this can expose you to some problems, as discussed below.

Here's a 140 x 21 ft. D-Kaz with Cat-5 extensions (reversible as we'll explain below). Note we measure height by the distance between the return wire and the Delta apex. Since the return wire is 2 ft. above ground, we have a "21 ft." height:



EXTENDING THE NULL-POT: THE DX-ER'S 'PANDORA'S BOX': Intuitively, one might expect that a copper-wire extension of the ends of the Deltas could upset the antenna balance and make it harder to do good nulling. Theorists may argue that this wire-extension doesn't matter in the RF domain…*as long as whatever cable extension used is properly matched to the end-point terminations of the antenna.* Thus, they suggest, a step-down transformer inserted at the antenna ends and matching a balanced transmission line will permit a 'reasonable' amount of such extension. DX-ers use lamp-cord, twin-lead and Cat-5 for these extensions. It turns out that, with the (900-ohm) D-Kaz, a 9:1 step-down nicely matches the Cat-5 110-ohm cable. *(Cat-5 is well-balanced twisted-pair **data cable**.)* Others may extend the antenna ends by using 18:1 transformers coupled to 50-ohm coax. All of us are reminded to also be aware that extensions may be susceptible to RF from strong local signals entering these transmission lines.

MUDDLED 'THINKING:' In our 2014 observations we had tried several lengths of Cat-5 transmission lines and noted that spans much beyond 100 feet or so started to make results a bit snarky…though those effects were somewhat mitigated by the use of *equal-length* lines. At the end of the day we had chosen a spot for our observations at the antenna's mid-way point (20 feet away from the array). For a 140 ft. antenna that meant about 80 ft. for each transmission line. Things worked well at that length; reliable F/B performance was realized. So---Cat-5? No problem. :-)

Where we got into trouble in the desert version was in forgetting the hinky results we saw last summer. (In the desert we laid out two D-Kaz antennas separated by 340 feet so we could run the array in "Broadside.")

In the desert version, with the "shack" in the middle of our array, Cat-5 extensions would be about 200 feet. But initial measurements showed shallower F/B nulls than we were used to. We wasted a lot of time at this point. First, we misled ourselves with "sweep tests" using a RigExpert 600 antenna analyzer, during which we analyzed Cat-5 runs from 50 to 250 feet. The Cat-5 was terminated in the antenna balun, with a 900 ohm 'dummy load' resistor in place of the antenna. All lengths delivered very good SWR and Phase results. So we felt certain that the Cat-5 *couldn't* be the problem.

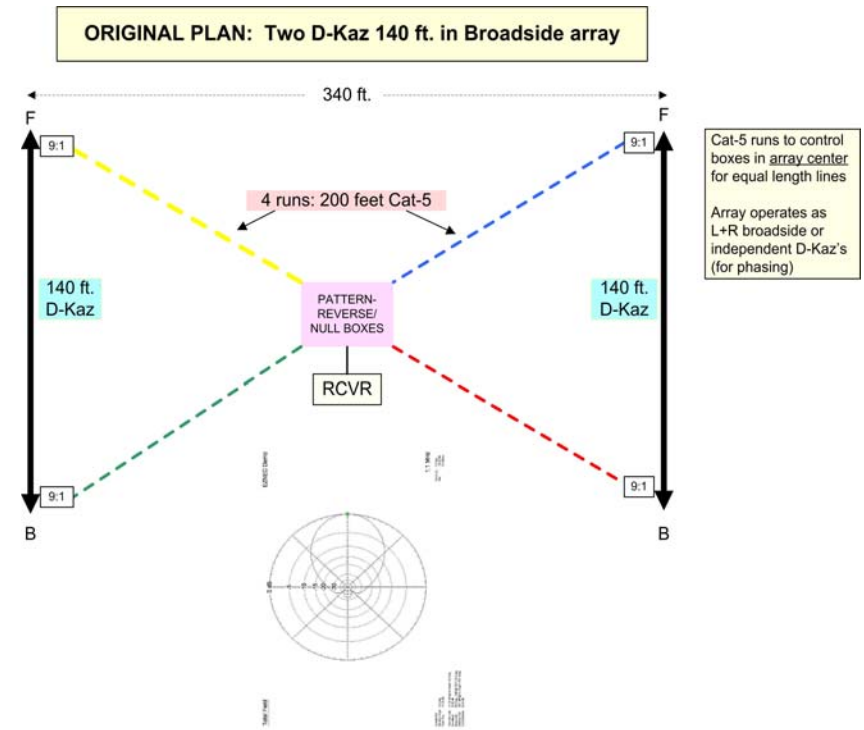
Something must happen to a fellow's deductive powers under the high-altitude hot desert sun. Our D-Kaz antennas with their 200 ft. transmission lines just weren't working right and we didn't know *why*.

It wasn't until we tore out a bit of hair trying to get good F/B numbers that we went back to the original idea of placing the null-pot right on the antenna. BINGO! It thus wasn't a great leap to conclude we couldn't use 200 feet of Cat-5 to extend the null-pot. It just took us a couple of days *to remember this* <g>

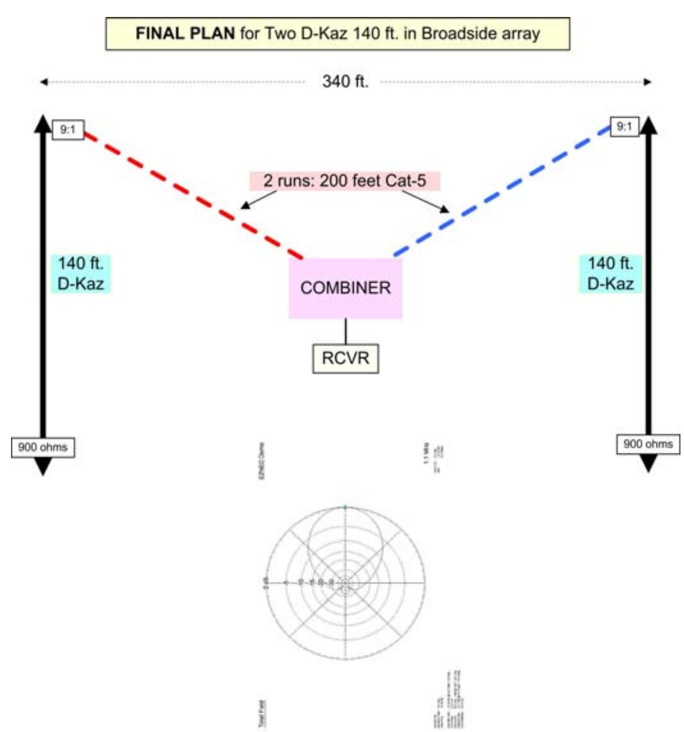
We do believe this issue applies *only* to the extension of the null-pot resistor and are now waiting for wiser minds to show us we're wrong**.** In our final desert set-up, a 200-foot run of Cat-5 was used to extend the receiver feed back to the 'shack' and that worked fine…with the null resistor at the antenna. Further careful measurements at another location now verify that as a transmission-line for the *receive* side, extended lengths of Cat-5 (or other *balanced* cables do not materially impact performance.

FORTUNE FAVORS THE BRAVE: At this point we did a run on target signals off both ends of the antenna and found that a 900-ohm (!) fixed resistor did a pretty good average job of nulling across the band. So the null pots hanging on the antenna ends were replaced by fixed resistors. The antennas now performed identically, delivering nice nulls. We were ready to "Broadside" them.

BROADSIDE--THE ORIGINAL IDEA: This was the initial paper plan. Even at the point-of-planning we had forgotten the 2014 warnings about extended-length Cat-5 lines.

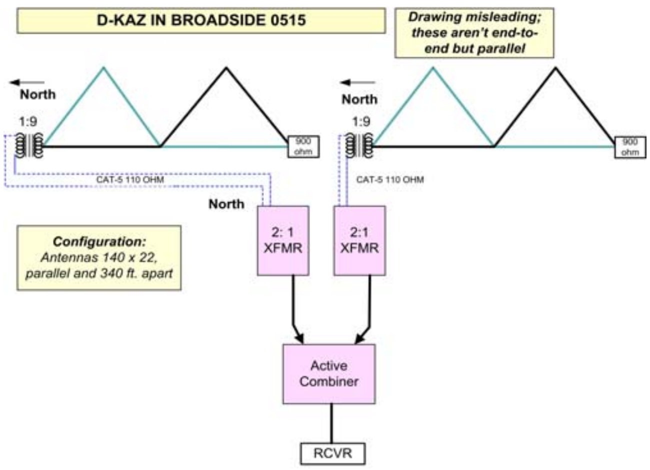


REALITY:

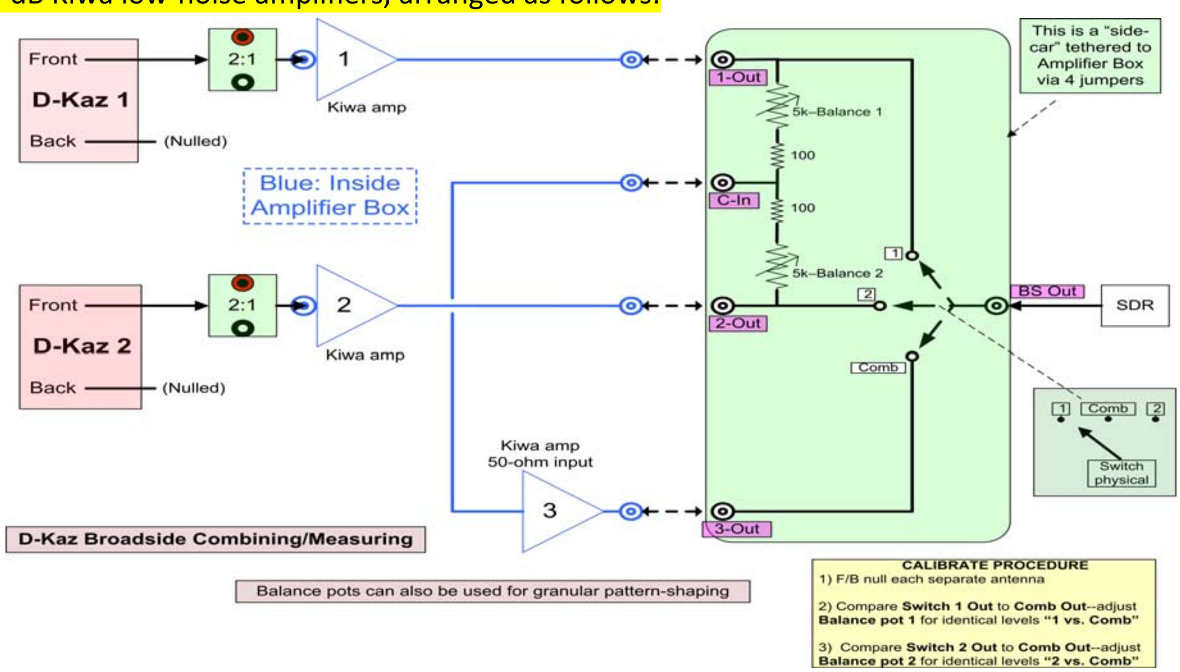


WHY 340 FEET? The EZNEC modeling predicts the best separation for two elements is from 0.53 to 0.55 wavelengths. **Kaz advises: "**Once you get beyond that, while the main beam becomes even more narrow side-lobes start creeping up and when less than that the main beam is not as narrow as it could be."

THE BROADSIDE D-KAZ: This variation of the D-Kaz has great promise. Adding the parallel element narrows the beam-width of the array and reduces side-lobes. The resultant pattern begins to challenge the Beverage. The electric equivalent for the final Broadside (*the antennas are side-by-side, not inline, as perceived here*):



The Broadside results made worthwhile every agony we had endured under the hot desert sun. A two-element Broadside array requires two D-Kaz antennas to be combined in phase. We built an "RF mixer" using three 10-dB Kiwa low-noise amplifiers, arranged as follows:



The "balance pots" also allowed us to calibrate the array with a solid surface-wave signal (KSL 1160). (One of the D-Kaz antennas was flipped out-of-phase and the balance pots were adjusted for *best null* of KSL.)

The Broadside set-up. (Note that this shot was made while we were still struggling with remoting BOTH receive and null ends of the two antennas.)

The top unit contains a 4PDT 'flip-flop' for comparing the two D-Kaz antennas individually. The right side is the active RF mixer. The middle unit contains the three Kiwa RF amplifiers as seen in the wiring diagram above. The lowest unit is a 4-wire terminator/antenna-reverser for analyzing remotely-terminated antennas…the VOM is on a 'push-to-measure" switch for quick readings of null-pot resistance.

Once we had simplified things by inserting null resistance right at the antennas, the wiring above got simpler and after our KSL null-adjustment we started evening runs with the SDR…as the terminator moved west. Among the interesting results; we caught some west-coast stations still on DAY power while most of the path from us to them was in darkness but sunset had not yet arrived at their towers.

UPON FURTHER REVIEW: A few seconds after we started listening to the recordings it became obvious that a Broadside D-Kaz was very good at scrunching side-lobes and furthering F/B performance, while apparently tightening the main front lobe. The result was that we found a lot of stations in front of us that got through over the objections of many other co-channels that would have shown up on an antenna with a wider acceptance angle. For example:

0580 KIDO over nearby KUBC and at 0590: KID and KQNT over KSUB

0690 Tiny KRCO over KEII just north of us (even if KRCO was on day power, that's just a kilowatt).

0770 KTTH wiped out powerhouse KKOB as did CHQR.

0790 61-watt KSPD stood out among six or seven co-channel neighbors (even day power is but one kilowatt).

1060 Daytimer KBGN still on after Sunset; it and KFOY over flamethrower-jokester CKMX and nearby KDYL.

1090 KFNQ overcame closer hotshot KBOZ.

And so on. 1270 KAJO held up over several closer neighbors. We copied three of seven 1300 available signals (KAPL, KLER and even KKOL)…all three in the Broadside's bore-sight. On 1450 KCLX came up from Colfax WA among dozens of GY'ers. All in all, well over one hundred new call letters for the log book.

And so, our experience with the D-Kaz in the desert reinforced the forgotten original experience that the best array configuration seems to be an *average null resistance attached directly to the antenna*.

BROADSIDE-BROADSIDE? Kaz continues to stay a few steps ahead. His modeling suggests we ought to add at least one or two more elements to the broadside array. This of course is appealing only to those who are gluttons for punishment (and have a spare desert lying around, for the space needed). Using the active RF mixer shown above it would require little additional *electronic* effort to combine additional elements.

SUBSEQUENT MEASUREMENTS; DIFFERENT VENUE: In May 2014 we were back at the site of our original transgressions where we established a 140 x 22 ft. single D-Kaz and this time used #16 wire. At this time we verified the relative insensitivity of transmission-line length on the receive side and worked all measurements with a null-pot directly connected to the deaf side of the antenna. The first interesting thing we discovered is that predictable nulls were achievable using average null-R values…but now they centered on 800 ohms, rather than the 900 ohms we anticipated. Kaz advises this is an expected value, given the larger wire size.

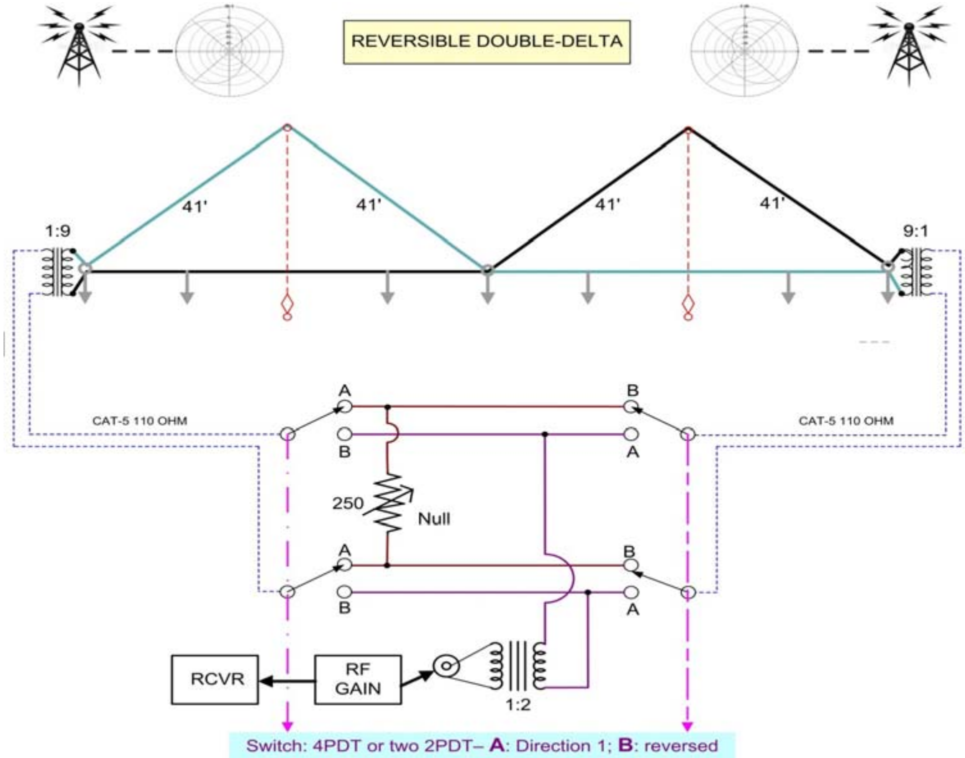
We expanded the tests by deliberately varying the calculated average resistance and confirmed by F/B performance that we were indeed on the sweet spot, at around 790 ohms with #16 wire.

Our next step will be to apply one of Mark Connelly's varactor-based remote-null controls. Properly isolated, this should allow us to extend the nulling function without compromise.

THE D-KAZ REDUX: ORIGINAL NOTES: This update supersedes the notes on our initial experimentation with a single D-Kaz in 2014. Most of those notes are deleted now (but available by request). We HAVE left intact below our ideas on how to build a D-Kaz…as well as the following thoughts on the ease of configuring the array for easy reversal.

PATTERN-REVERSAL: A significant appeal of this antenna is its reversibility and this is most useful when you have remoted *both* ends of the antenna…with risks as qualified above ☺. This is done by electrically swapping receiver and null-pot ends. As noted, the 9:1 step-down at the ends of the antenna meant the native antenna impedance of 900 ohms (this was with #18 wire) was taken down to just over 100 ohms. (A 2K pot provides good range when connected directly to the antenna; thus a 250-ohm pot at the end of a Cat-5 extension.)

Here's one way to do this:



All of this was combined with the RF amplifier and its batteries, into a compact termination system; seen here as the bottom unit (the rest of this lash-up will be explained in a later report on the desert DXPedition):

You'll note we added a 'push-to-measure" function for easy observation of null resistance at a given F/B adjustment.

For more-casual applications these ‘termination functions’ were combined in a mini-box we imaginatively called a “**Reverse/Null-box**.” Here’s that unit, along with other transformers and the null-pot used to directly connect to the antenna:

In this set-up the RF amplifier or receiver is connected to one of the BNC outputs on the bottom (the two BNC jacks are labeled “main” and “fellow DX-ers”). The Cat-5 extensions are connected to the top of the null/reverse box. (These functions were incorporated in the lowest of the three test units seen above.)

Pattern-reversal is as easy as flipping the switch. Here are 2014 logs showing how well this works; observations made in Minnesota, using short Cat-5 extensions. The lists show the “CO-’s” when an antenna flip is made and the “hot” side of the antenna is looking for signals from the opposite direction…and *no readjusting of the null-pot*!

Stations heard on opposite sides of D-Kaz 140-ft. antenna

Grid Square EN25 Copy at 4PM, 7PM, 9PM CDT 061714

	"North" (330 deg)		"South" (150 deg)	
600	KSJB	Jamestown ND	WMT	Cedar Rapids IA
620	CKCK	Regina, SK, CA	KNMS	Sioux City IA
680	CJOB	Winnipeg, MB, CA	KFEQ	St. Joseph MO
740	KVOX	Fargo ND	WDGY	Hudson WI
790	KFGO	Fargo ND	WAYY	Eau Claire, WI
810	KBHB	Sturgis SD	WHB	Kansas City MO
860	CBKF2	Saskatoon, SK, CA--NO ID	KNUJ	New Ulm MN
880	CHQT	Edmonton, AB, CA--NO ID	WMEQ	Menominee WI
890	KQLX	Lisbon, ND	WLS	Chicago IL
910	KCJB	Minot ND	WHSM	Hayward WI
950	KWAT	Watertown ND	KTNF	St Louis Park MN
970	WDAY	Fargo ND	KQAQ	Austin MN
980	KDSJ	Deadwood SD (poor copy)	KKMS	Richfield MN
990	CBW	Winnipeg, MB, CA	KAYL	Storm Lake IA
1080	KNDK	Langdon ND	KYMN	Northfield MN

1130	KBMR	Bismarck ND	KTCN	Minneapolis MN
1170	CKGY	Alberta, SK, CA	KRUE	Waseca MN
1220	KDDR	Oakes ND	KLBB	Stillwater MN
1230	KTRF	Thief River Falls MN	KMRS	Morris MN
1280	KVXR	Moorhead MN	WWTC	Minneapolis MN
1300	KPMI	Bemidji MN	WQPM	Princeton MN
1310	KNOX	Grand Forks ND	KGLB	Glencoe MN
1340	KVBR	Brainerd MN	KWLM	Willmar MN
1350	KDIO	Ortonville MN	KCHK	New Prague MN
1360	KKBJ	Bemidji MN	KRWC	Buffalo MN
1370	KWTL	Grand Forks ND	KSUM	Fairmont MN
1450	KBMW	Breckenridge MN	KNSI	St. Cloud MN
1470	KHND	Harvey ND	KMNQ	Shakopee MN
1480	KKCQ	Fosston MN	KAUS	Austin MN
1520	KMSR	Mayville ND	KOLM	Rochester MN
1660	KQWB	Fargo ND	KUDL	Kansas City KS

DEPLOYMENT OF THE D-KAZ; SOME IDEAS LEARNED THROUGH PRACTICE: You can set up one of these antennas in a half-hour or so. Here are the parts for a system with a 'shack-located' observation point. Follow the diagram on page 11.

Two short lengths Cat-5---or lamp-cord, twin-lead or coax extension cables.

Two 9:1 step-down transformers:

One 2:1 step-down transformer.

If coax is used to extend transmission lines, the 9:1 step-down transformers become 18:1 and the 2:1 step-down transformer is put back in the junk-box.

One 250-ohm null-pot.

RF amplification of 10 to 15 dB.

Four insulators for the wire-ends.

Two support poles. Kaz's find of a 22-foot "fish-pole" is great:

http://store.kittyhawk.com/22-Foot-Heavy-Duty-Telescoping-Windsock-Pole-P1432.aspx

Supports for these poles: Two 2-foot galvanized pipes. Kaz says: *"I use 1" ID pipes. 1" ID pipe has an OD of about 1.31" and the masts slide over that very nicely for a good fit…for a permanent installation if the ground gets saturated, the masts can slide further down the pipes and into the ground. This can be corrected with shims or simple maintenance raising the mast to proper height and packing in some dirt."*

DX-er Mike Shafer (who lives near our desert space) has come up with this suggestion for mast-mounting that includes directions for extending the D-Kaz to 30 feet:

Here is a picture of the Windsock mounted directly over a 1" X 3' piece of EMT Conduit driven 18" into the ground sleeved with a 1" x 18" thinwall PVC to make it a nice tight fit and provide a bit more electrical insulation. Next to it is the 1-1/4" piece driven about halfway into the ground. To the right is a picture showing how the three types of pipe sleeve each other.

Here is my recommended method for putting the 10' Extention on the windsock. This is a piece of 1-1/4" EMT Conduit (Made "pointy" for easier driving and dirt removal) driven into the ground with the piece of 1" Plastic PVC sleeved 1" EMT that is 10' long inserted. (Note that the 1-1/4" is cut to two feet but I only drove it in 1foot for demonstrations purposes. The PVC is also cut to 2' but dirt in hole is keeping it up a foot or so. Normally I might drive and clean 1-1/4 inch so that 1" insert would go a full 2' in ground, depending on soil and wind.

Here is a shot of the 30' extended Wind Sock pole. I had about a 7-10 mph wind when I erected it and it was very easily done even with the wire hanging on it. There very little additional bending to the Wind Sock pole extended since the conduit is very rigid

Back to the parts list:

Two pre-cut lengths of insulated stranded wire: #18 or larger; see comments on wire size vs. null resistance. If you're building a 140 x 21 ft. D-Kaz, the wires can be cut to 155 feet each; that'll give you a bit extra.

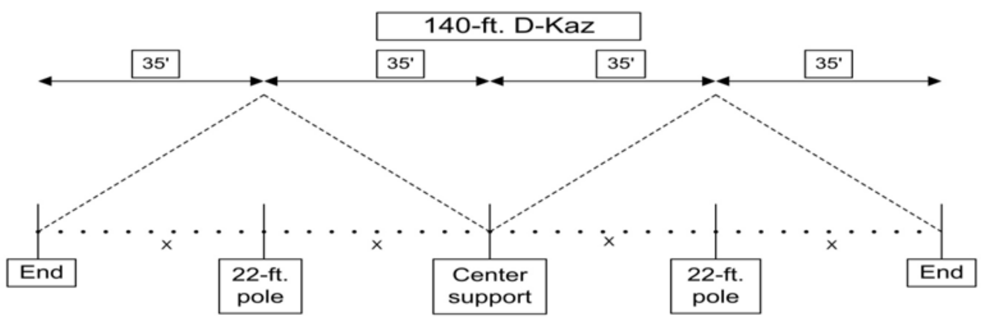
Wire-support stakes. The "return wire" is kept 2 ft. off the ground by these stakes. Home Depot sells these in 12-pack bundles; 3-ft, pre-cut with points. Drill a couple of holes near the top.

Alternatively (and easier to use as the middle wire-supports) are plastic electric-fence posts:

The center-support where the deltas cross is subject to some minor tension in the vertical plane. You can use a fixed wood stake…but we do something a little different. Here's our center-support pole. This is where each of the delta-triangle wires is landed and extended as the base of the adjacent delta:

We drop a short, small-diameter pole into the ground and slide a 1-1/4" PVC pipe over it, with holes drilled at the 2-foot level for the wire-crossings. The PVC can 'ride' up and down, and by its weight puts a soft tension on the wires so the deltas keep their shape. We used a four-foot PVC for enough weight to put a small amount of tension on the wires; note our PVC is lifted slightly above ground, indicating that tension.

PHIELD PHOLLIES OR SIMPLE CONSTRUCTION? And that leaves one item: how to erect the antenna. We offer one fellow's version of how the D-Kaz antenna can be easily deployed:



1. Spot the center post location; pull out a tape measure in each direction along the azimuth you want, marking the 35 foot and 70 foot spots. Drive in the center stake/support first.

2. Drive in the two end supports, in line with the center. The insulators go on the end posts.

3. Place the intermediate wire supports about where the "X"s are.

4. Drive in the pipes that will hold the support poles. Pull out the *top section only* and lay the 22-ft. poles on the ground at their locations.

5. Now tie one of the wires to an end support, thread the other end through the close-by 22-ft. support pole, then through the center support and through the X supports to the other end.

6. Reverse the procedure, starting the second wire on the opposite end, through its nearby 22-ft. support pole, through the center support and the X supports to the other end.

7. Carefully open the 22-ft. support poles to their full height; they should be lifting their wire as you do. Insert the support poles onto their pipes.

8. Now you can go to the ends, gently pulling each wire tight until the deltas take shape. Then tie off those wires to the end stakes. If you're using our center-support idea, proper tension is when you observe the PVC rising slightly as you pull on the wires.

9. Connect your equipment. That's it! You should be able to do this in less than a half-hour.

We hope you found something of interest, and that perhaps our more-recent desert experience will remind you…as it did us…that the answers continue to evolve and that YOUR MILEAGE MAY VARY!

Two D-Kaz's in Broadside (hills are on the back side of the antennas)

73 and good D-Kaz DX!

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