A 50 MHz CONTEST ARRAY THE 2007 VERSION

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2007 was a rebuilding year for my six meter antenna system. The antenna system consisting of four long yagis had been in place since the mid 1980's. The genesis of that first six meter project in1985 was my attempt to minimize the dead zone effect on 50 MHz between troposcatter and ionospheric scatter. This effect produces a dead zone from about 350 or 400 miles out to about 600 miles. Tropospheric scatter is the primary vehicle for communication ranges up to about 350+ miles (560 km) Beyond that range, communication is not normally possible until ionospheric scatter paths become viable at 600 miles or more. Scatter from the ionosphere occurs at a much higher altitude than the normal tropo scatter, making it the effective mode at the longer distances.. Missing grids at these "Dead Zone" distances hurt my contesting score! My thinking then was that a very high angle of radiation was needed to enhance the ionospheric path for shorter hops.

The first array version consisted of a 90 ft tower and four vertically stacked Cushcraft 617-6B yagis with beam steering. They were in use from 1985 until the big ice storm of 1998. They did not survive the 4 ½" of ice load during the storm, and were replaced with some home brewed computer designed 7 element yagis on a slightly shorter boom length of about 31 ft. These yagis have been in use up to the present time.

The original configuration was the subject of several talks and presentations in New England and at the Mid Atlantic VHF Conference in 1989. [1.] At the time, I mentioned that the whole project was a work in progress, and that the lessons learned from using such an array would be incorporated into a new and more optimum setup as time permitted. Over the years from 1985 until now, I have seen many interesting facets of six meter contesting. In addition, I had a few ideas of how to better optimize an array for VHF contesting. Six meters is a very interesting band that cannot make up its' mind whether to be an HF band, or a VHF band. It exhibits characteristics that approximate first one and then the other! Sometimes, this happens at the same time.

My design goals for the new antenna system were as follows:

1. The array must have a wide E plane or horizontal beam width
2. It must have a high gain "option".
3. It should be fully rotatable and fast, with accurate phase fronts while turning
4. It must have a choice of adjustment of propagation arrival angles to match what is commonly seen on 50 MHz. Up tilt should help "close in" ionospheric scatter somewhat.
5. It must be capable of pointing in several directions at once for versatility during VHF contesting.
6. It must have a clean pattern to minimize extraneous QRN and QRM.
7. The height of the array needed to be increased to allow better performance of the lower yagis. (A lesson learned from the old array)

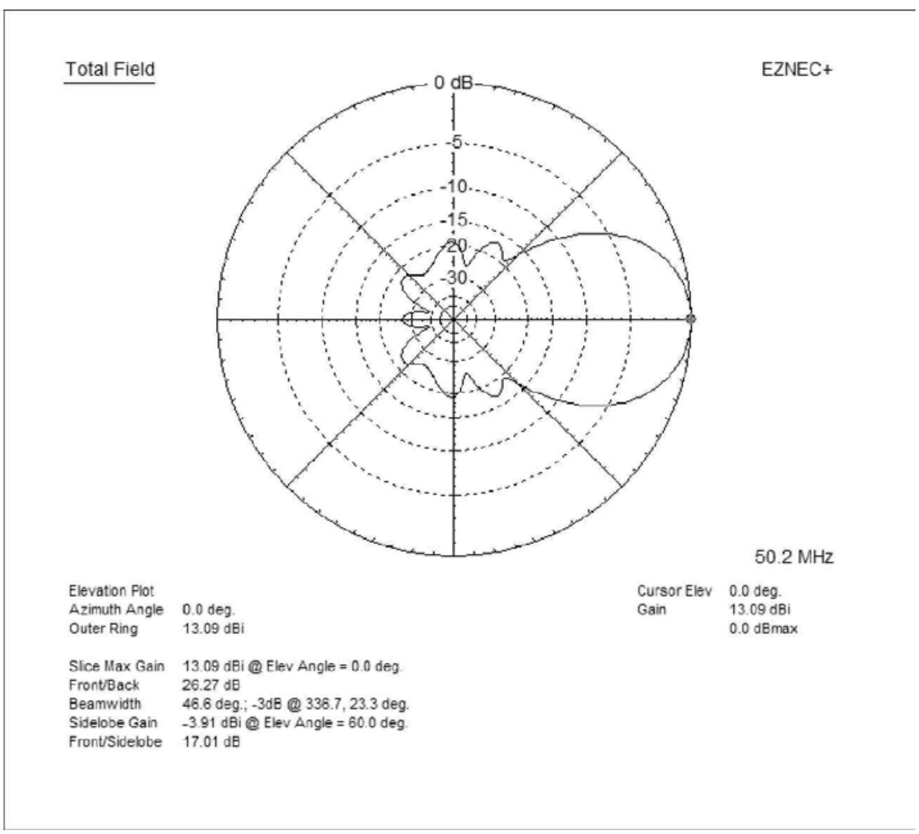
The new antenna system built in 2007 consists of a 100 ft Rohn 45 tower with the top two sets of guys made with Phillystran non conductive guying cable. In addition, the three side mounted yagis are all perched on TIC Ring rotors for full 360 degree rotation with no phase changes as it moves around the tower. The top yagi uses a conventional rotor inside the tower. This capability is a big improvement over the old system. The old design was only partially rotatable, and was at a big disadvantage by being so limited. Still it provided a good test bed for new ideas. In addition, the new antenna heights were raised slightly for improved results. The bottom antenna went from 18 ft up to 29 feet.

We had trouble with rfi in the shack on the old antenna, when that 18 ft bottom antenna was being used. Another impetus to change was the condition of the old bolt together tower. It had sharp edges and climbers risked minor injuries during climbing sessions.

Looking at the existing revised 31 ft yagi from 1998, I was very happy with the results. I did not see any need to update the design at all. It was a redesign of the old 617-6B yagi. That original antenna was an early computer optimized yagi, referred to as a Chen and Cheng design after the IEEE authors who developed it.[2] It had very high gain, but a narrow bandwidth and a poor H plane pattern and poor front to back or F/B ratio. The design was cleaned up to reduce the rear lobe with a shortening of the last director. Still, it left something to be desired as it came "out of the box". The new design was computer optimized, and developed more gain than the 617-6B along with a much better pattern. It had many good points.

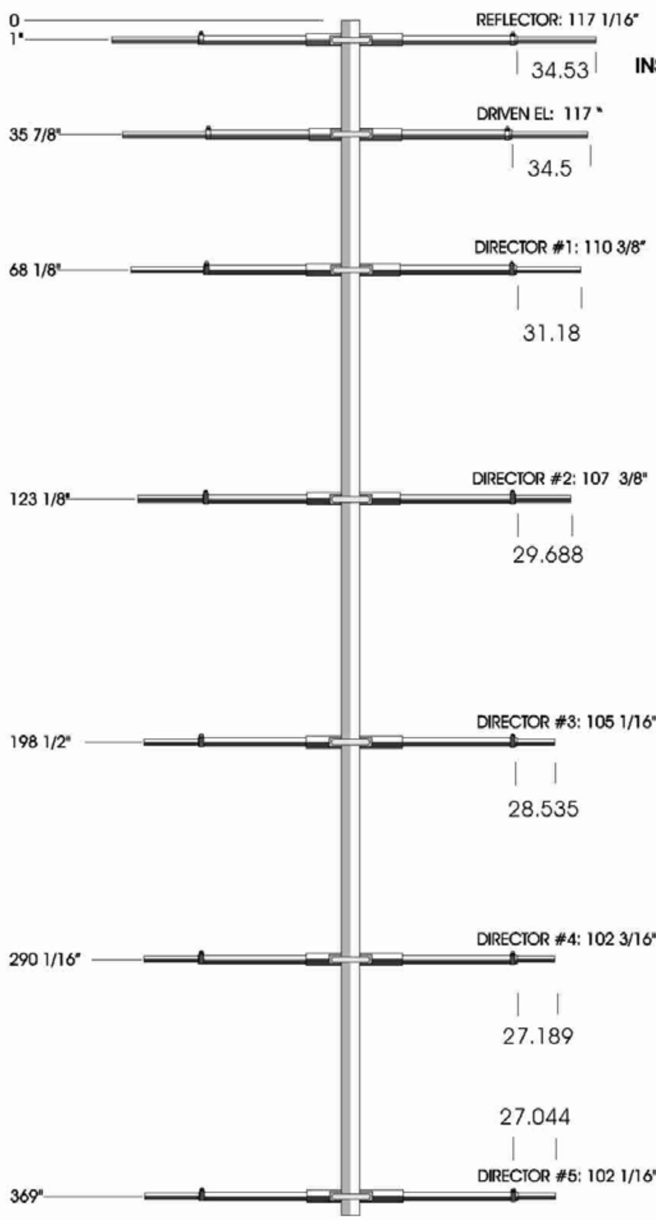
1. Improved bandwidth over the 617-6B
2. 11 dBd forward gain in free space
3. 25 dB or better F/B ratio
4. Good side lobes in the E and the H plane. A clean H plane pattern helps tame vertical lobes when stacking.
5. Shorter boom to fit under the guy wires. just under 31 ft. vs. the 34 ft for the 617-6B
6. More rugged bracing design to survive bad ice storms (hopefully!)

The patterns for the revised antenna are reproduced here. In addition a three dimensional plot is included that gives a different perspective of a clean pattern.



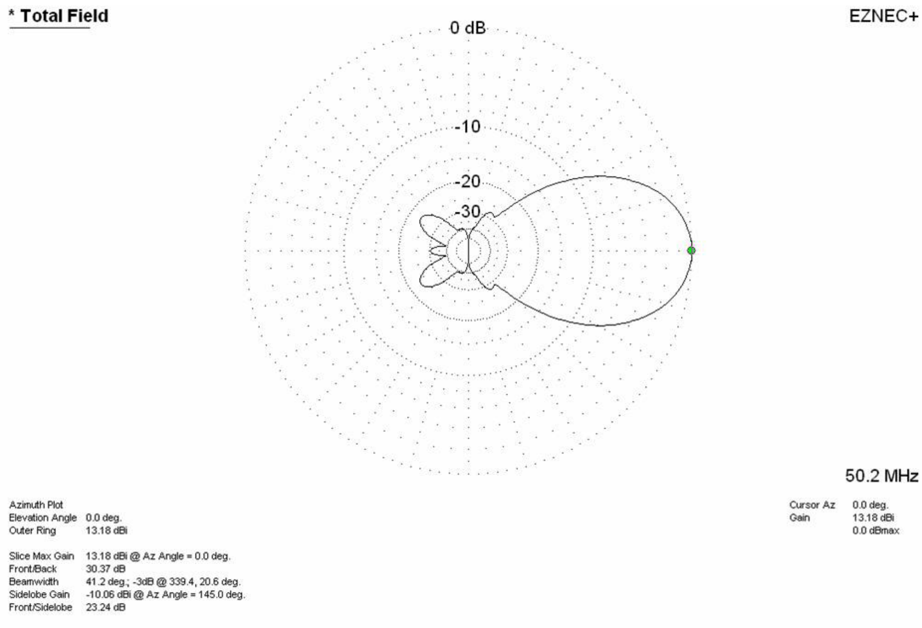
H Plane pattern for K1WHS seven element 50 MHz yagi in free space

K1WHS 7 ELEMENT 50 MHz Yagi

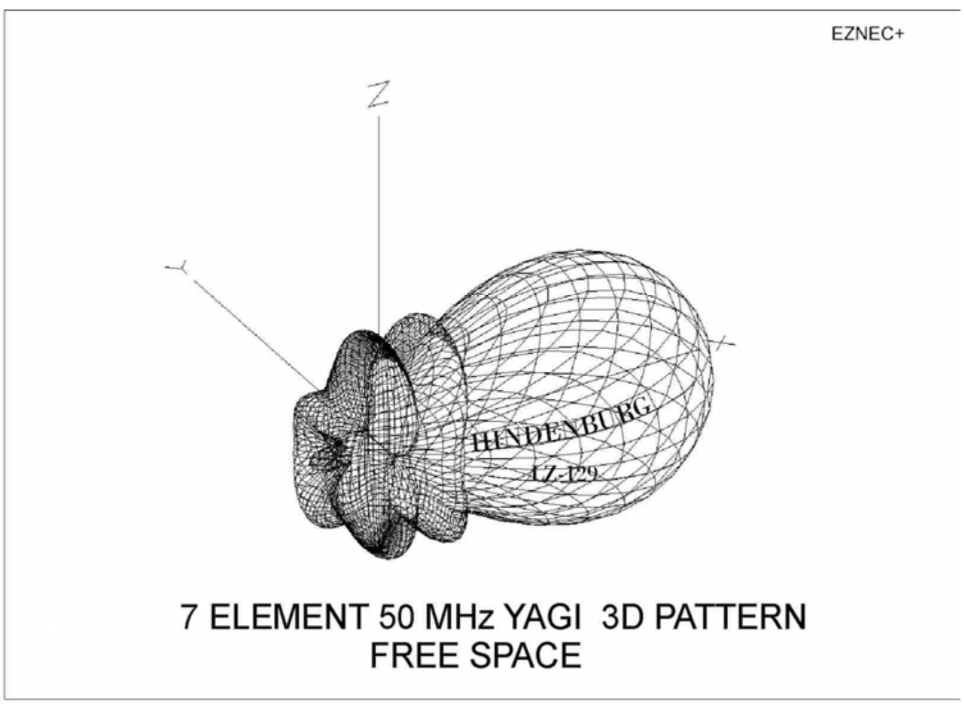


ELEMENTS ARE 3/4" DIA X 48" CENTER PIECES WITH 5/8" INSERT SECTIONS ONE EACH END.. SLOT EACH END OF THE 3/4" PIECES AND USE A STAINLESS WORM CLAMP TO HOLD INSERTS IN PLACE. ANTENNA IS PEAKED AT 50.5 MHZ AND GIVES GREAT PERFORMANCE ACROSS 50-51 MHZ. MEASURED 1ST SIDE LOBES ARE -24 AND -28 dB. F/B IS -24 dB. BEST MATCH IS -35 dB TYPICAL AT 50.5 MHZ. USE STANDARD 617-6B TEE MATCH.

Boom is made from 2" OD aluminum tubing. The ends can taper to a smaller size. Elements are fastened with 2" long u bolts and aluminum saddles. The boom is braced with 3/4" aluminum tubing supports.



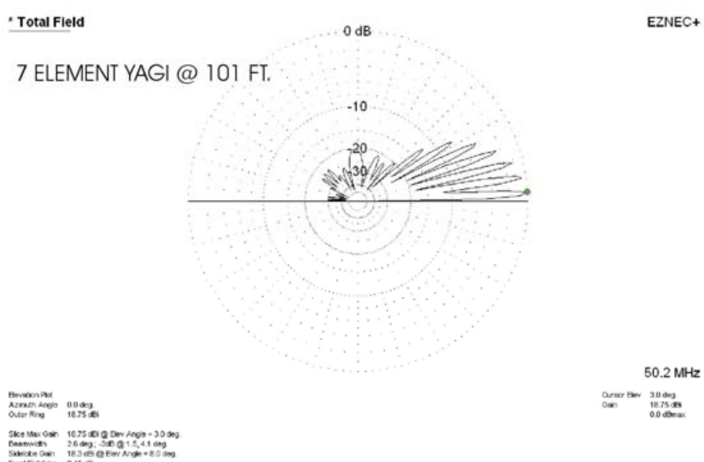
E Plane Pattern for K1WHS seven element 50 MHz yagi in free space



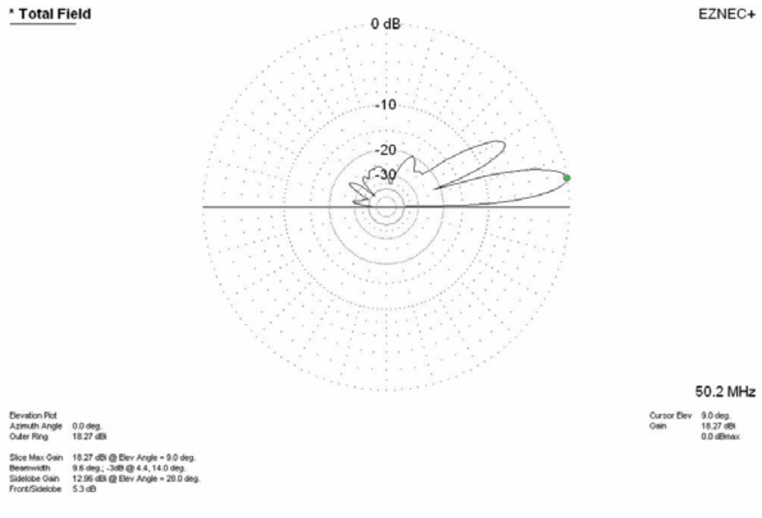
I have verified the pattern at 50.2 MHz. in the real world, with the E plane side lobes at about 24 to -28 dB, and a front to back ratio of at least 25 dB. This was done on an antenna range setup with the yagi at 30 ft above ground, and using a balanced dipole for a source antenna. The results were close enough to make me confident that the antenna was performing as it was predicted once I had put the design on the right frequency.

Getting back to the array design goals, the main idea of any successful antenna is to match the antenna to the propagation at hand. At HF frequencies, contesters and DXers use terrain analysis software (HFTA) and adjust the height and number of antennas on a particular band so as to make the main lobe of the antenna match the arrival angle of the incoming signal. There are published arrival angle percentages for each band in the ARRL Antenna Handbook.[3.] What you do not want is a big null from a ground reflection cancellation occurring at the angle that produces the most DX!! Every band is different, but at HF, the angles of interest go from zero degrees up to about 15-20 degrees of elevation. On 10 meters, for example, most angles are between 3 and 8 degrees to Europe. 9-12 degrees occurs about 25% of the time. There are no published figures from 50 MHz, as any ionospheric openings are rather fleeting at 50 MHz. We can make assumptions, however. For any F2 openings that reach 50 MHz, one would assume that the MUF is hovering slightly above 50 MHz. There are rare cases where the MUF has gone as high as 70 MHz at mid latitudes, but these conditions are fleeting. Actual use of the old array from 1985 to 2006 provided priceless information on 50 MHz arrival angles. For about 90% of the time, arrival angles were at 5-6 degrees or lower during any opening. This included Sporadic E and F2 type conditions. The other 10% of time produced better signals with some 10 degrees of elevation applied. The higher radiation angles are still needed to eliminate that "beyond troposcatter dead zone".

So how do you know what your antenna pattern will look like? EZNEC and YO both provide vertical patterns for antennas above a ground plane. Generally, a low antenna will provide a fatter vertical lobe, which is good, but with some elevation tilt upwards above the horizon. Not good! As the antenna is raised, nulls from ground wave cancellation of the direct (or sky) wave will become very prominent. These nulls can cause all sorts of problems if they are present at the same angle as the desired DX. Here are some illustrations of the situation. I am using predicted patterns for the vertical lobe on the new six meter array.



Vertical plot of K1WHS Seven element 50 MHz yagi at 101 ft over ground

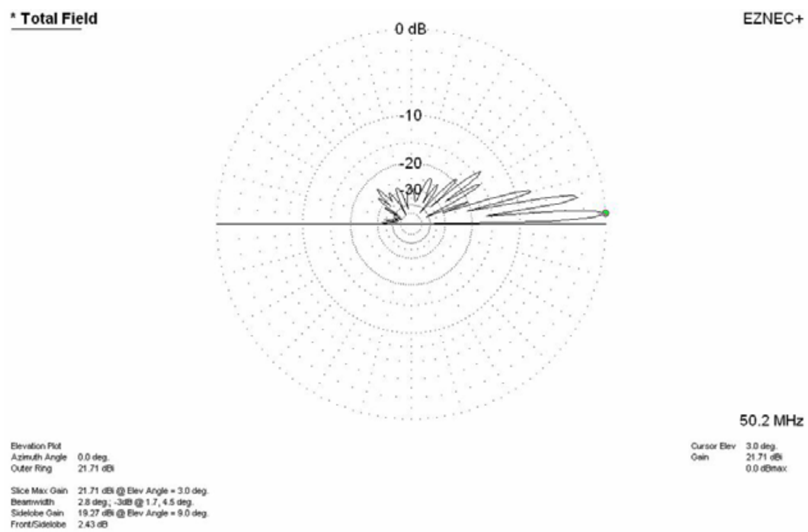


Vertical plot of K1WHS Seven element 50 MHz yagi at 29 ft over ground

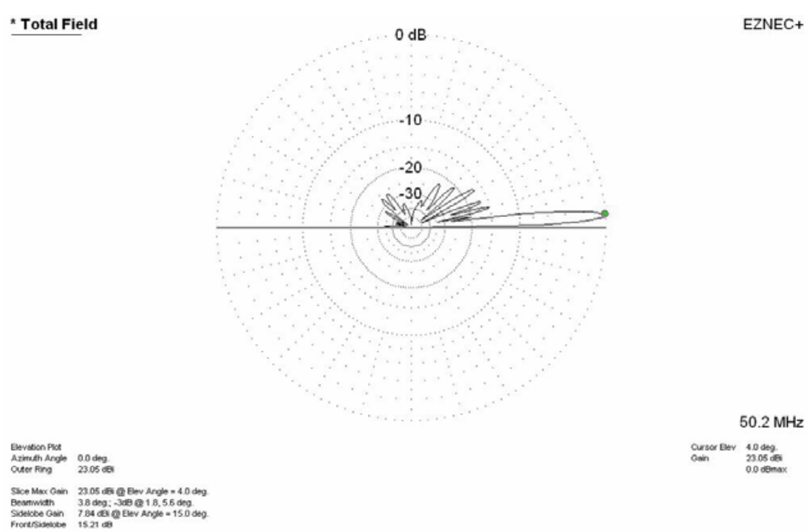
You can see that the high yagi has all sorts of nulls, but it does have a "killer" lobe on the horizon. The low antenna covers more angles with only one null, but suffers from a relatively high angle lobe that is not good for long haul contacts. This would preclude any contacts when the band is just trying to open, when all the arrival angles are close to the horizon! Now the HF guys try to optimize the situation by siting the yagis to remove any nulls from the angles most likely to produce DX. They have an easier time, as most HF antennas are smaller in terms of wavelength, than the typical six meter yagi. There are few seven or nine element 20 or 40 meter beams for example. [4.] The patterns on HF are therefore much wider. The nulls tend to be fewer.

My approach to an optimum six meter array was to essentially have my cake and eat it too. I was not sure which arrival angles were the optimums, so my approach was to make the antenna adjustable and move the vertical lobe to match the conditions. This choice maintains the high gain of a stacked array, but with the ability to respond to more angles of radiation. The requirement for a wide relative horizontal or E plane beam width was met with the seven element design. It had a clean pattern which tends to fatten the main lobe. I have 41 degrees of horizontal beam width. The vertical H plane -3 dB beam width is 46.6 degrees. Forty one degrees is fairly wide and can cover a wide swath of territory, but it can also tend to remove QRM or QRN if needed. To get extra gain I simply stack more antennas vertically. This also eliminates many of those high angle side lobes that do not help with hearing and working DX on 50 MHz. A vertical stack of yagis will squash the vertical lobe, while keeping the E plane or horizontal lobe constant.

What are the advantages of stacked antennas over a huge single yagi? First and foremost, you can easily develop more gain than a single yagi with a pair of smaller yagis. You pick up almost 3 dB with proper stacking compared to about 2.2 dB or so by doubling the boom length of a single yagi. A vertical stack of yagis will maintain the same wide horizontal beam width of a single yagi, by compressing the vertical lobe only. Those vertical lobes often do not contribute to better performance at all. A longer single yagi by comparison, will be sharper and create aiming problems. Long yagis also put excessive strain on rotating systems. In addition, multiple antennas are effective in controlling QSB or fading effects during periods of enhanced conditions. This is a big advantage for stacked yagis. An array of several yagis will cover quite a range of vertical heights and effectively reduce fading effects. This is very noticeable on the four yagi stack. Lastly, you can vary the takeoff angle by manipulating the phase relationship between the pair of yagis, or pairs of yagis, to produce a better, or more versatile performing antenna, something that is not possible with a single yagi!



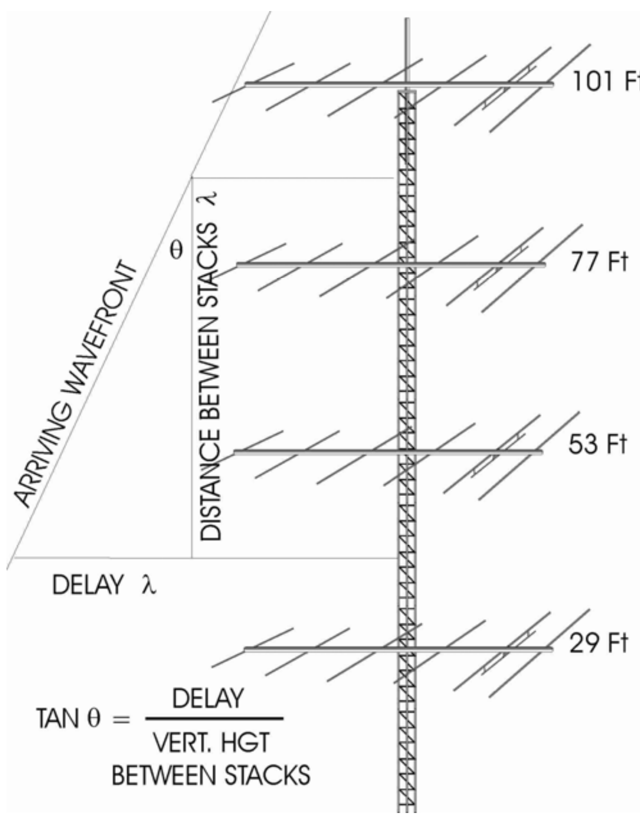
Vertical plot of 2X K1WHS Seven element 50 MHz yagi at 101 & 77 ft. over ground



Vertical plot of 4X K1WHS Seven element 50 MHz yagi at 101, 77, 53, & 29 ft over ground

A few trends are obvious. When you stack antennas vertically, the main lobe gets narrower in the vertical plane, but the take off angle on the first lobe is not reduced. The only factor affecting the take off, or arrival angle, is the height above ground. When you stack two antennas, the actual elevation angle is always a bit higher than the angle of the higher antenna by itself. In our case, with an antenna at 101 and 77 ft., the radiation angle would be that of a single antenna midway between those two heights, or 89 ft. What is also noted, when antennas are stacked vertically, is that those higher angle lobes are suppressed, and more power is put into the lowest lobes that will do you the most good. This is a very important point. It is easily seen in the plots shown.

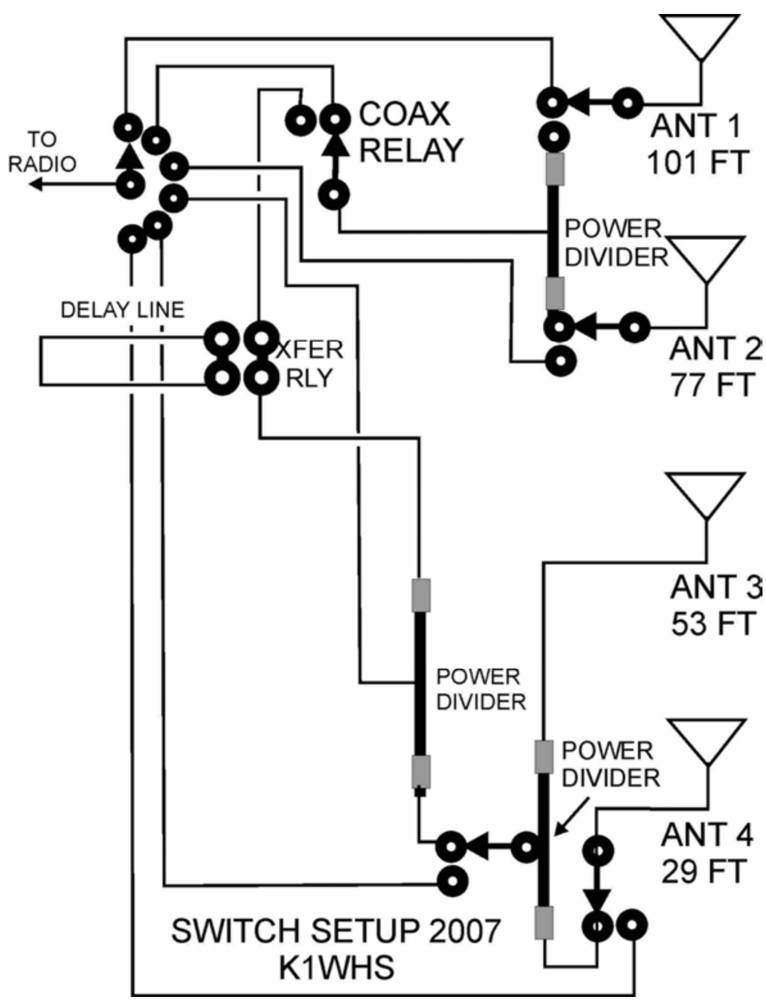
We still have a problem with this antenna configuration, however. The 2X stack, and the 4X stack still have nulls near the horizon. The top two yagis have a null at 7 and 13 degrees, while the 4X stack has a null at about 9 degrees, and no response above that number! If any DX arrives from that angle, you are out of luck! My solution to this situation is to apply some beam steering to the array to fill in those nulls with a flip of a switch at the operating position. On the 4X stack, for example, a phase delay of coax cable to the top two yagis will produce a lobe at 9 degrees where the null used to be. If any signal is arriving near that null, the phase switching should take care of it. True to form, there are times when the signals are stronger with the up tilt. Other times, the signals are better with no tilt.



This trigonometric formula is useful for small angles only. Use the same units for all measurements to approximate your take off angle. The picture demonstrates the mechanics of up tilt. "Delay" is the cable length needed. (Allow for Vp)

An arriving wave front that is elevated will contact the top antenna first, and will produce an out of phase condition, as the bottom antennas will not have a signal at that point in time, that matches the phase from the top. If we insert a section of delay line to the top two antennas, we can optimize an arrival angle that is above the horizon, by making all of the arriving signals additive for that specific angle. The delayed signal from the top two yagis will arrive at the array center in phase with the bottom two yagis. Now the "on horizon" signals will be out of phase!

So how do we introduce this phase shift in a real antenna? You could put a bunch of relays and cables out on the tower, and utilize transfer relays to insert sections of 50 ohm cable in series with the top two yagis. This puts a strain on all that hardware, as it is out in the weather, and requires all sorts of control cable to make the desired changes. After going the outdoor route in 1985, and getting tired of fixing stuff, I opted to remove all the power dividers, relays, and delay lines, and run four equal length feed lines into the ham shack. Now I can do all my matching and phase trickery indoors. Below is a schematic of the RF cabling circuit I am using at the present time.

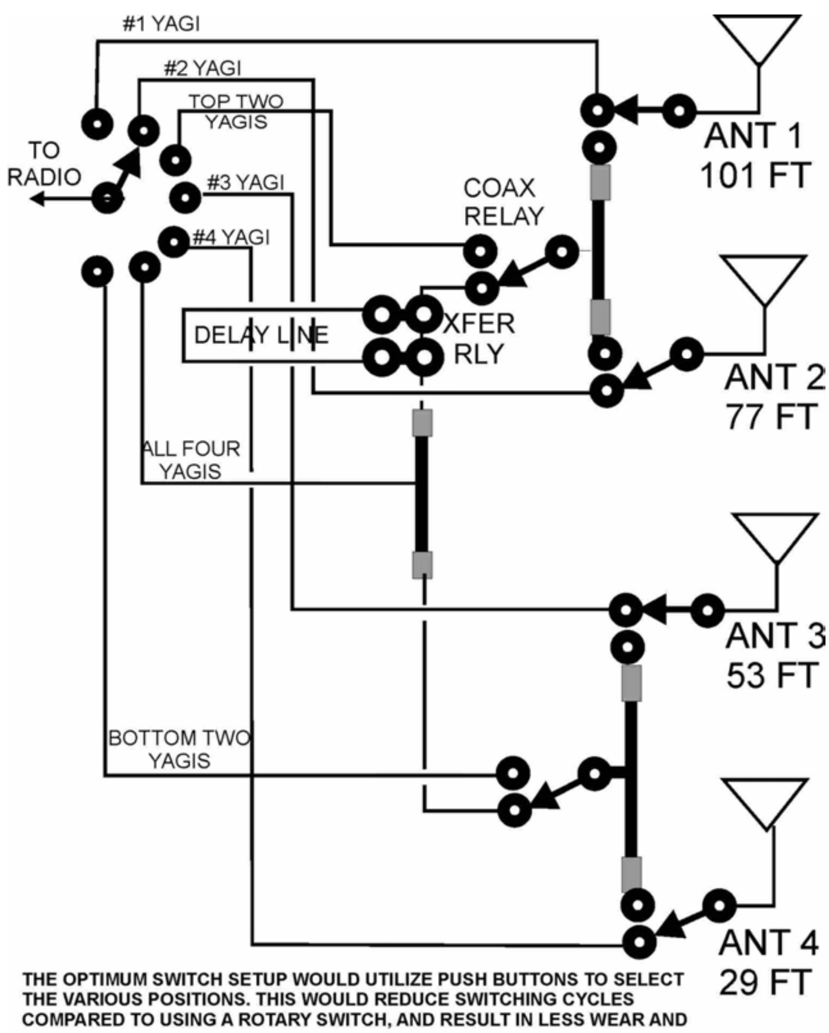


Existing relay and delay line schematic 2007/2008

This schematic (previous page) shows three power dividers and five Dow Key type coax relays, along with a transfer relay and a six position coaxial relay. The choices obtained as the six position relay is run through each position are as follows:

Position 1	Top antenna only energized
Position 2:	101 & 77 Ft yagis both driven in phase
Position 3:	77 Ft yagi only
Position 4:	All four yagis operating in phase with no delay.
Position 4A:	All four yagis operating with phase delay. (Transfer switch is activated to add the delay line)
Position 5:	Bottom two yagis at 53 and 29 ft in phase
Position 6:	Bottom yagi at 29 Ft only.

A better implementation might be to rearrange things a bit to allow more variation in antenna choices. I have included another schematic as a way to get more options. This arrangement, shown below, seems more flexible than the original design.



Of course, you are limited by the number of positions you have on your coaxial relays. It has been my experience that you really don't need too many options to cover all of your bases. This second implementation has the advantage of being able to run all antennas individually or in combinations. This can come in handy during contests, when you are looking at specific directions. You could have each antenna pointing at a different spot to avoid slow rotor movements and wasted time.

I modeled each configuration on EZNEC to determine typical arrival angles for the different combinations of antennas.

Top Antenna at 101 ft.	1.5-4.1 degrees	18.75 dBi
Second antenna at 77 ft.	1.8-5.4 degrees	18.88 dBi
Top two yagis 101 & 77 ft.	1.7-4.5 degrees	21.70 dBi
All four yagis in phase	1.8-5.3 degrees	23.10 dBi
All four yagis with up tilt	6.7-10.6 degrees	22.00 dBi
Bottom two yagis at 53 & 29 ft.	3.0-9.4 degrees	20.72 dBi
Bottom yagi at 29 ft.	4.4-14 degrees	18.30 dBi

The choice of arrival angles is most different when the up tilt position or the bottom yagi alone is chosen. The other positions are somewhat similar in performance, and this is borne out as the various positions are chosen while listening to DX signals. There are very interesting observations seen in actual use, however. When you add more yagis, the forward gain goes up. This is obvious as the signal improves. At any given time, a quick switch back to a single antenna might show only a small decrease in signal from the two stack or even the four stack. At other times, the difference can be on the order of 20 dB or more. Time variations to see this, may be on the order of from several seconds to about 15 to 30 seconds! This is only noticed on Es or F2 signals. Local tropo scatter signals seem to be well behaved by comparison. On local signals, there is a 3 dB improvement going from one to two yagis, and a 6 dB improvement when going from one to all four yagis. This disparity between propagation modes can be explained by a constantly varying arrival angle on ionospheric propagation paths. As the path changes, the angle can, and will, pass through the nulls in the antenna pattern. This is one cause of the familiar QSB that we see on sporadic E signals as well as some F2 signals. (Anyone remember F2?) The arrival angle does not seem to change on local or troposcatter signals. There are also polarization and ground effects that contribute to fading as well.

One feature of a stacked yagi system with up tilt available, involves improving the signal to noise ratio. Providing up tilt reduces power line noise as well as local QRM from energetic hams on SSB. The splatter level is quite high when the band opens. Local signals will be attenuated by the up tilt, while, oftentimes, the DX station will be more clear with up tilt. Many times during both the CQ WW VHF Contest, and the ARRL September QSO Party, the beam up tilt feature was used to improve reception in the presence of one or two strong local stations that were splattering terribly. This trick also can help with power line noise. The noise drops faster than the arriving signals.

Sporadic E signals are quite common in the summer months, and the typical QSB variations heard during any opening are quite familiar to most operators. Listening to a specific Es or F2 event on a multi yagi vertical stack is quite interesting. The first thing you notice is that the QSB is drastically reduced. Signals seem to hang in there longer than with a single yagi. And if you think you might be imagining things, you are constantly being reminded by those whom you work, that your signal seems to be very constant, and not prone to fading out. The drastic reduction of fading is not quite due to true diversity, but is related to the way ground reflected and the sky wave signals impact with your antenna. If the ground reflection and sky wave signals cancel out at 101 ft, and you had your antenna perched there, you are out of luck. There is no signal. But if you have other antennas at 77, 53, & 29 ft., the chances of a cancellation at those other heights is very small. When all the signals combine, in the middle of the harness, the array output may be only 3 dB down instead of 25-30 dB from a complete cancellation.

Some Performance Observations

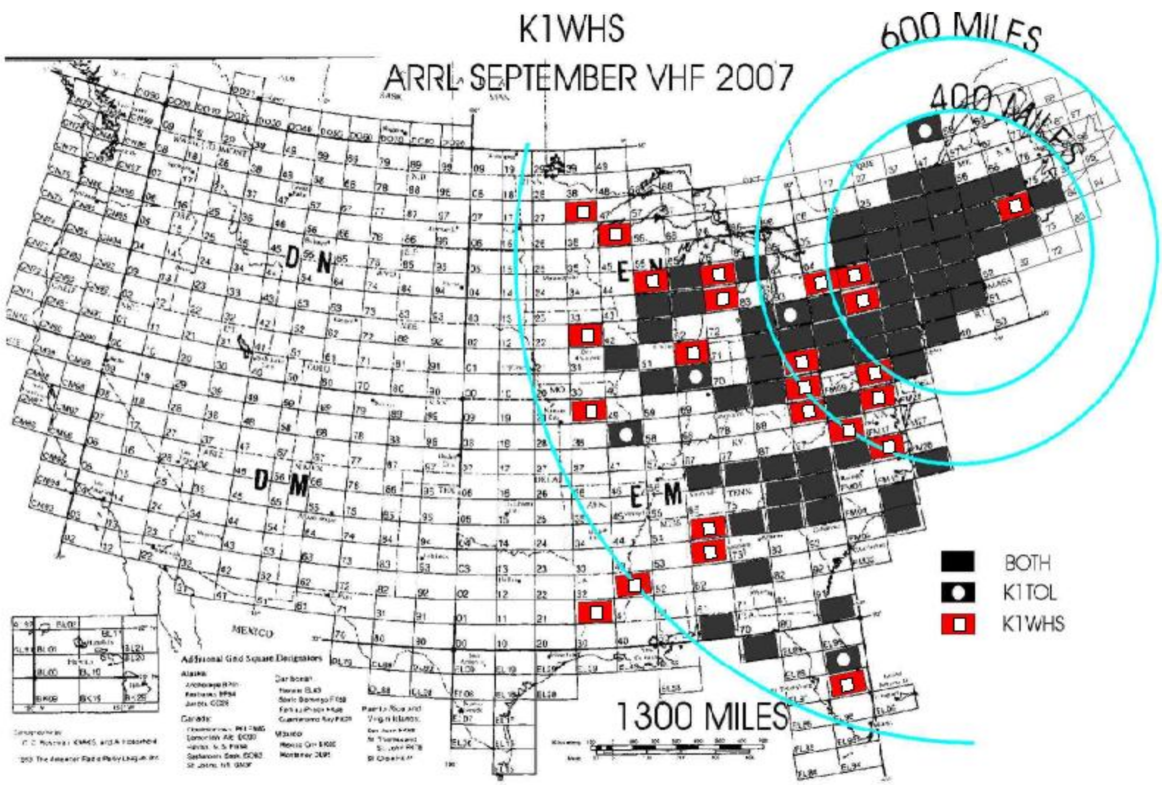
On June 25, 2007 a strong European Es opening occurred when the array was only half built. I had two yagis in place and rotatable towards Europe. This was the first time I could ever aim two antennas at Europe, and the results were spectacular. The band opened in the afternoon, and I listened for about an hour in my shop on a small yagi. Signals were weak but steady. When the band stayed open for an hour, I decided to play "hooky" from work and sneak away to my real ham shack for about 1 ½ hours to "work the band". What followed I had never heard before. I made many CW contacts, and then went on SSB on 50.169 or so. The pileup was so intense, that it was impossible to make out any calls or even letters. The frequency became smooth broad S8 white noise for about 30-45 seconds, until enough stations stopped calling and I could pick out an occasional letter. Needless to say, I did not run a huge rate during the intense periods, but still managed to work about 115 Europeans in that time. Both antennas were in phase and on the horizon. I had to quit early. I heard that Hawaii was in a few hours later!!

In the CQ Worldwide VHF Contest, on July 25, 2007, I managed to complete the four yagi array just that morning, and K1BX arrived that afternoon to operate in the contest. I figured it would be a good test to check out the performance, and compare signals on the different antennas. The band opened up Saturday afternoon, with some propagation to Europe, but K1BX concentrated on the areas that had the best propagation, and snagged only two grids in Europe before looking elsewhere. Sunday was dead for the entire day, however. He ended up with 793 QSOs in 179 grids, which was the top six meter score in the country. He out pointed some big efforts from K8GP, K3EAR, K5QE, K1TOL and K2DRH. K8GP and K3EAR are mountaintop stations. Surely the propagation Gods were smiling on FN43, but the array performance was instrumental in keeping us near the top of the competition.

In the ARRL 2007 September VHF QSO Party, the new array produced the top 50 MHz score in the Northeast ahead of W2SZ, K1TOL, W3SO etc. but behind K8GP and K5QE nationwide. There was no good Es propagation for us, and the diesel generator started dying Sunday morning, requiring QRP operation, and then we were forced off the air entirely by early Sunday evening when the genset died completely. We managed 84 grids and 455 QSOs. From the results obtained so far, it seems that this array is capable of staying competitive, grid wise, with some other large stations in the Northeast. I would have to say that the array versatility may be the main reason.

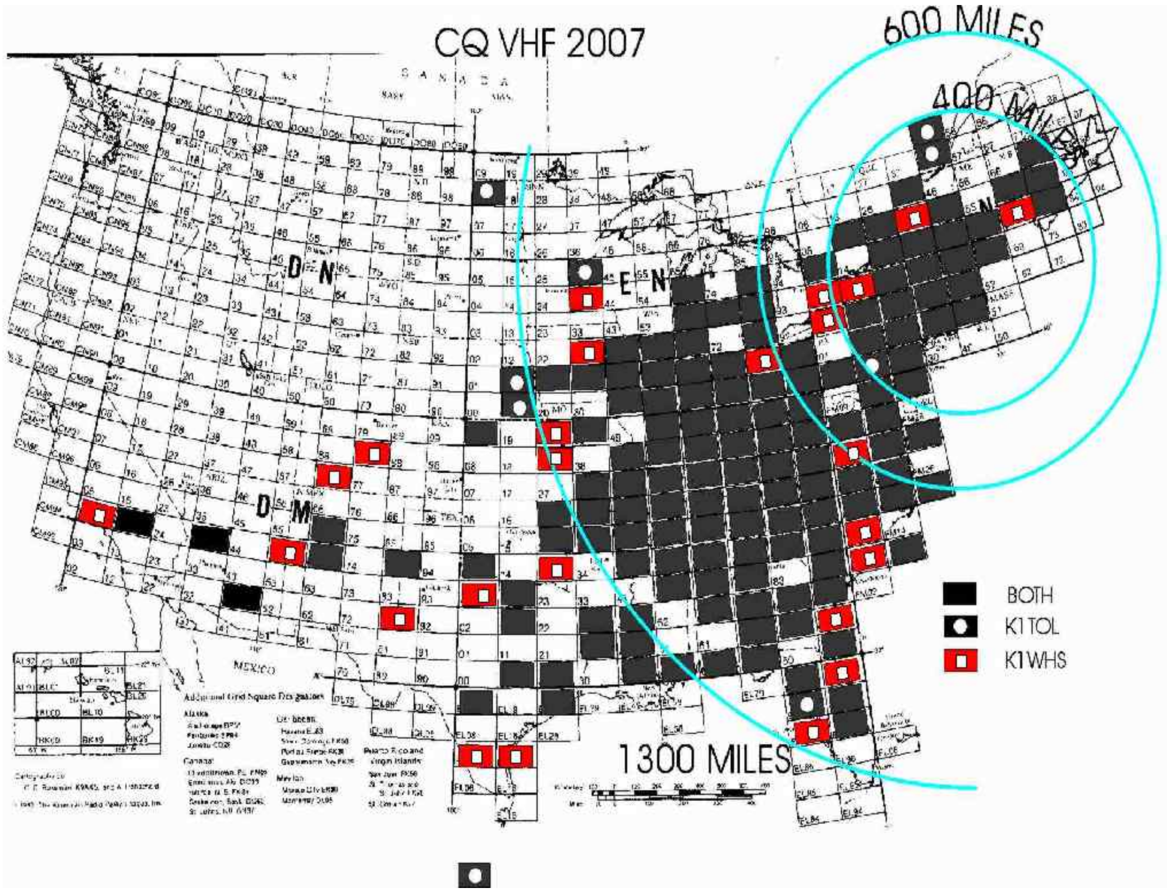
Delving further into these two vhf contests, I wanted to get an idea of the efficiency and versatility of the new array, by comparing results with other stations. On the air comparisons are difficult in many cases as conditions are not equal across the country. The September contest was a good example. There were great Es conditions in the south central part of the country, but northern New England was shut out of most of the action. I tried some comparisons with K1TOL, also located in Maine about 50 miles to the North. Lefty has a truly super station with two towers devoted to 50 MHz. One tower has four 7 element 34 ft yagis fixed southwest, and a second Rohn 55 rotating tower is decked out with four 50 ft 9 element commercial yagis and a stackmatch box. K1TOL had operated as the six meter op at K1WHS for a few years, and decided to build an antenna patterned after the old array that he used here. The rotating tower and the large 9 element yagis at his place are the end result of his operating periods at K1WHS.

I was particularly interested in seeing how the new array worked in filling in those difficult dead zone grids in the 400 to 600 mile range (640-960 km.) In comparing logs with K1TOL, I tabulated the grids worked from both locations, paying attention to those intermediate dead zone grids. The maps produced, show that it is hard to work those distances, but a definite trend shows up. The following grid map for the September VHF QSO was generated.



The legend shows grids in black that were worked by both K1TOL and K1WHS. Black grids with a white circle are grids that were worked only by K1TOL. The red grids with embedded white squares, were worked only by K1WHS. The dead zone is indicated between the 400 and 600 mile circles. You can see FM26, FM27, FM28 and FM17 were not worked by either station. The same is true for FM09 and the grids in Canada, FN04, FN05, plus EN93 and 94. To the East there are no grids worked at all! These eastern grids are largely unpopulated with six meter hams. The few who are active there, have small stations, making QSOs to that area a definite problem. Tallying up all those grids showed that K1WHS worked 20 grids in the 400-600 mile range, while K1TOL worked a total of 12 grids. K1TOL missed FN13 and FN12 which are just at or under the 400 mile minimum. I allowed only one of those grids to count in the totals. K1TOL did work EN92 whereas we did not. I think a conclusion can be drawn from this comparison. Beam tilting to maximize the scatter volume does make a difference. Interestingly, the distances beyond 1200 miles also produced more grids for K1WHS over K1TOL. I cannot explain this with station hardware alone, for K1TOL has similar towers with yagis that are 20 ft longer and have about 1.5 dB more gain. Everything being equal, I would suspect that K1TOL would do at least as well. A comparison of locations brings up an important fact. K1TOL is located on slightly sloping ground to the West, but with higher obstructions a few miles distant, while the K1WHS tower is on a ridge with a gradual and long slope to the West and Southwest. This sloping ground and clear horizon tends to provide additional lowering of the radiation angle. Flat ground predicts a 3-4 degree angle for the 4X stack, but if the ground slopes away, the angle will be even less. A check of both sites produced horizon angles between -0.20 and +0.24 degrees at K1WHS, and 0 to about +0.50 degrees at K1TOL with beam headings between 220 to 300 degrees. I suspect that the 20 vs. 12 grid results over 1200 miles (1900 km.) is due to the QTH differences and a lower takeoff angle here.

I tried to compare the results of the CQ World Wide VHF Contest in July as well. The results were very hard to interpret, since there was Es present at times on Saturday with rather short skip that allowed filling in those problem dead zone grids.



The results shown here are muddy. The dead zone produced 20 grids for K1WHS and about 17 or 18 for K1TOL. In addition, the grids around 1200-1300 miles are inconclusive. Obviously, the Es conditions have clouded the crystal ball, but K1WHS worked a few more grids around 1200 to 1300 miles. I would hate to draw too many conclusions from this contest analysis, as much depends on operating strategies employed while the band was open. K1TOL worked a number of European grids while K1BX was knocking off stateside grids in the far West on early Saturday evening. Lefty, K1TOL, was switching back and forth between EU and stateside at that time with his two antenna systems. He worked many more EU grids this time. The only conclusion to be drawn from this second map is that the "dead zone" really does exist even in times of fair Es activity. The beam steering seemed to help marginally in this contest. Anytime you can keep up with a massive and effective station with a savvy operator like K1TOL, you should be thankful!

We were rebuilding the six meter tower and antenna system while the ARRL June contest was going on in 2007. We installed the top yagi by late Saturday, and ran that single yagi on Sunday of the contest. N1DPM, one of our September Contest ops, near Springfield, Massachusetts heard it and said he never heard us as loud in the past. He thought we had all four yagis back up!! It was at that point that we started to suspect that the insulated guy system may have made a big difference. The old array was surrounded by steel guy wires that were unbroken by any insulators. As the new array went together that summer, I could switch between 1 2 and 4 yagis and would see the signals increase as antennas were added. In the past, with the old system, the top two yagis together were about 3 dB better than a single yagi, but adding the two bottom yagis to the mix only improved things marginally over the two on local tropo paths. The current system produces a huge improvement when all four are combined. I estimate it is about 1.5 or 2 dB better than the old one in relative improvement. Better phase relationships among the yagis with the TIC rotors and the use of Phillystran could be the reason. The missing small trees also help. All of these changes are small, but they all seem to add up to produce a very effective six meter contesting station that is a joy to operate.

The rebuilding of the array has resulted in a system that is working much better than the original one ever did. The old system was a good performer, and always produced good contest scores, but new performance levels have been reached after the modifications were put in place in 2007. A summary of all of the improvements made will give insight into what is needed to optimize your system.

1. All antennas were raised by about10 ft. The bottom antenna went from 18 to 29 ft. There had been rfi issues with the original lowest yagi at 18 ft. Its' aperture also included some shrubbery within. That is not good. The rfi issues were improved by a great margin.

2. The guy wires were replaced with large diameter Phillystran insulated guy line.

3. All four ½" Heliax feed lines were replaced with 7/8" Heliax. The cables were each phase matched with full wavelengths removed from the shorter runs.

4. All four antennas are able to rotate in all directions. The old "barn door hinge" rotation devices were eliminated. These caused phase errors while turning, and are not optimum ideas for 50 MHz. The antennas needed to be supported below the ring rotors for best results. The metal from the rotor rings detunes the yagi element nearby.

5. Trees in the vicinity were removed. They affected the lowest antenna in the past. Two small trees seem to have made a slight difference.

In conclusion, it is safe to say that careful thought and attention to the small details does make a difference on any band, whether it is 50 MHz or 2304 MHz. This upgrade utilized the exact same antennas as in the old system, but gained a performance advantage of several dB minimum over the old array. Coupled with the features of the older array such as beam steering, the performance is very good. In some directions, the improvements are in a different league. I never had four yagis that could ever point at Europe or the Pacific Northwest with the old system, for example. The changes there should be breathtaking.

Rebuilding the antenna system was not a one man job. I would like to thank the following hams who helped with the heavy lifting and scrounging duties: WA1T, K1OR, K1CA, W1SD, KU2A, K1DY, WW1M, and WB2ONA. Thanks also to Steve, N2CEI for

initially suggesting that I scrap the old tower, as he would not climb it anymore! (It really was an ugly hulk.) He also kept running out of bandages.

References

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3. The ARRL Antenna Book, 21st Edition American Radio Relay League, Newington, CT 06111

4. http://www.K3LR.com Look at 20 Meter station #1. It is a similar array, but on 20 meters!