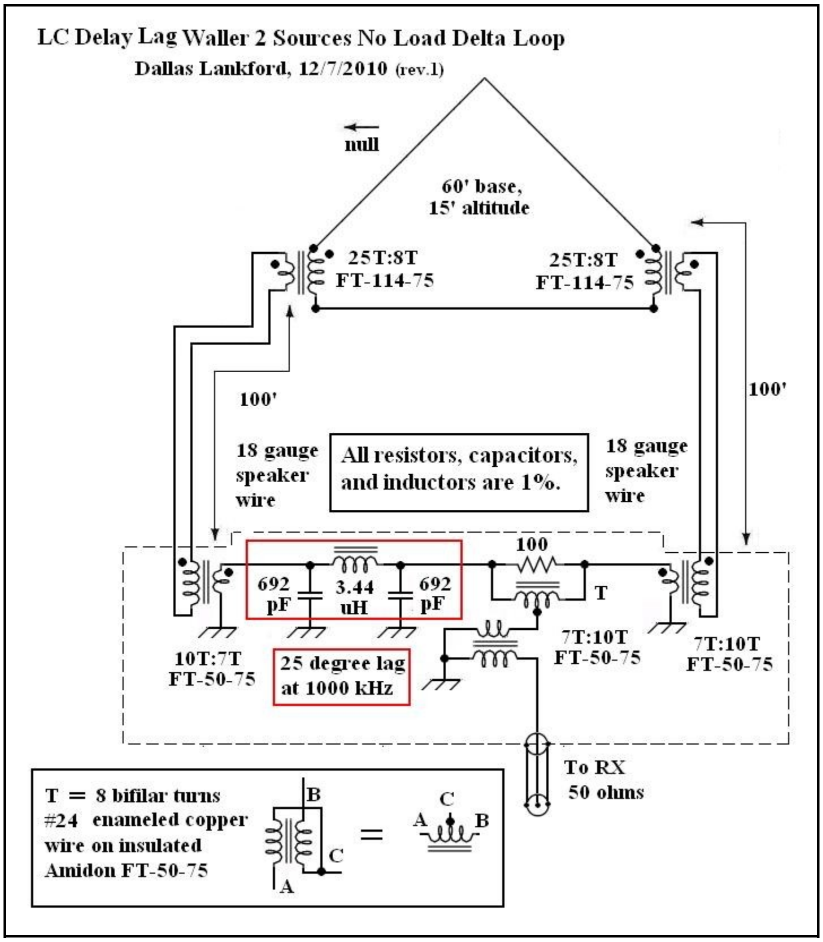
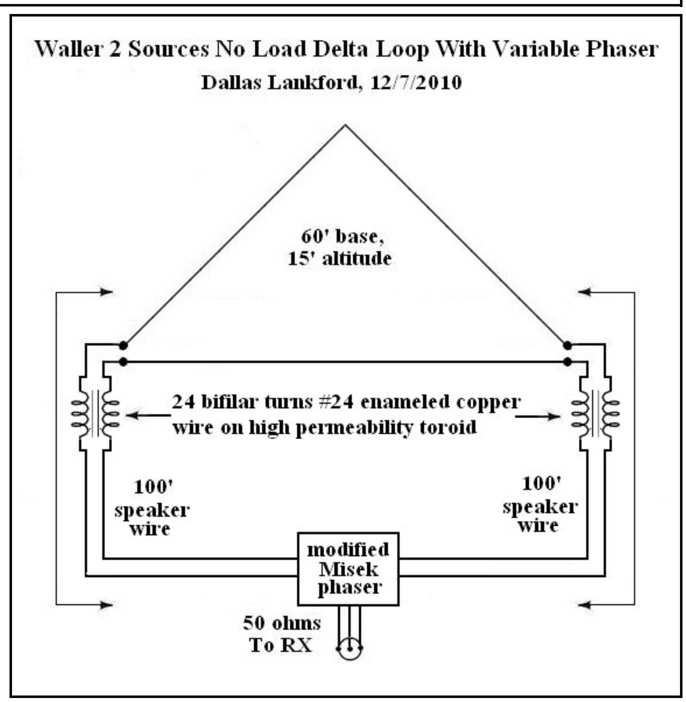
2 Sources Per Loop 0 Loads Loop Arrays

Dallas Lankford and Doug Waller, NX4D, 3/31/2011, rev. 4/3/2011

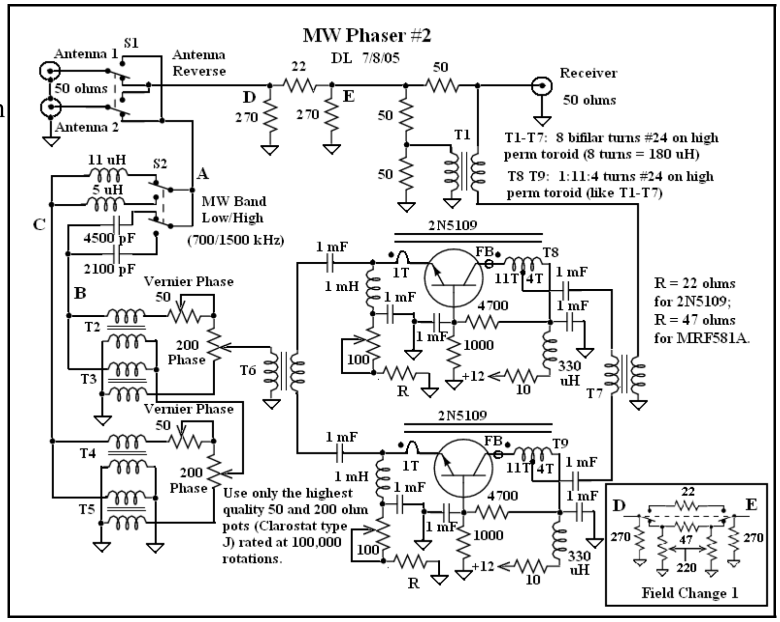


On 12/7/2010 Doug introduced me to his new antenna discovery, a 2 sources 0 loads single (not dual) loop which according to EZNEC had the same pattern as a single flag, but which had a much higher dBi gain than a single flag. Too good to be true? I simply had to find out. So Doug sent me his EZNEC file from which I could obtain phasing information. He remarked that one of the sources of the 2 sources no loads antenna, hereafter called 2SNL, had a negative input resistance, like 4 square vertical arrays. Not being aware of this, I went to the W8JI web site, but all technical information about the 4 square array had been removed. I looked at dual vertical arrays with EZNEC, and they also have one source with negative resistance (do an SWR and swap sources if the default source does not have negative resistance). A Google on negative antenna resistance found one article, but the method of that article for treating negative resistance was to resonate one or both verticals. I am not interested in narrow bandwidth arrays, and in any case that method did not discuss receiving loops.

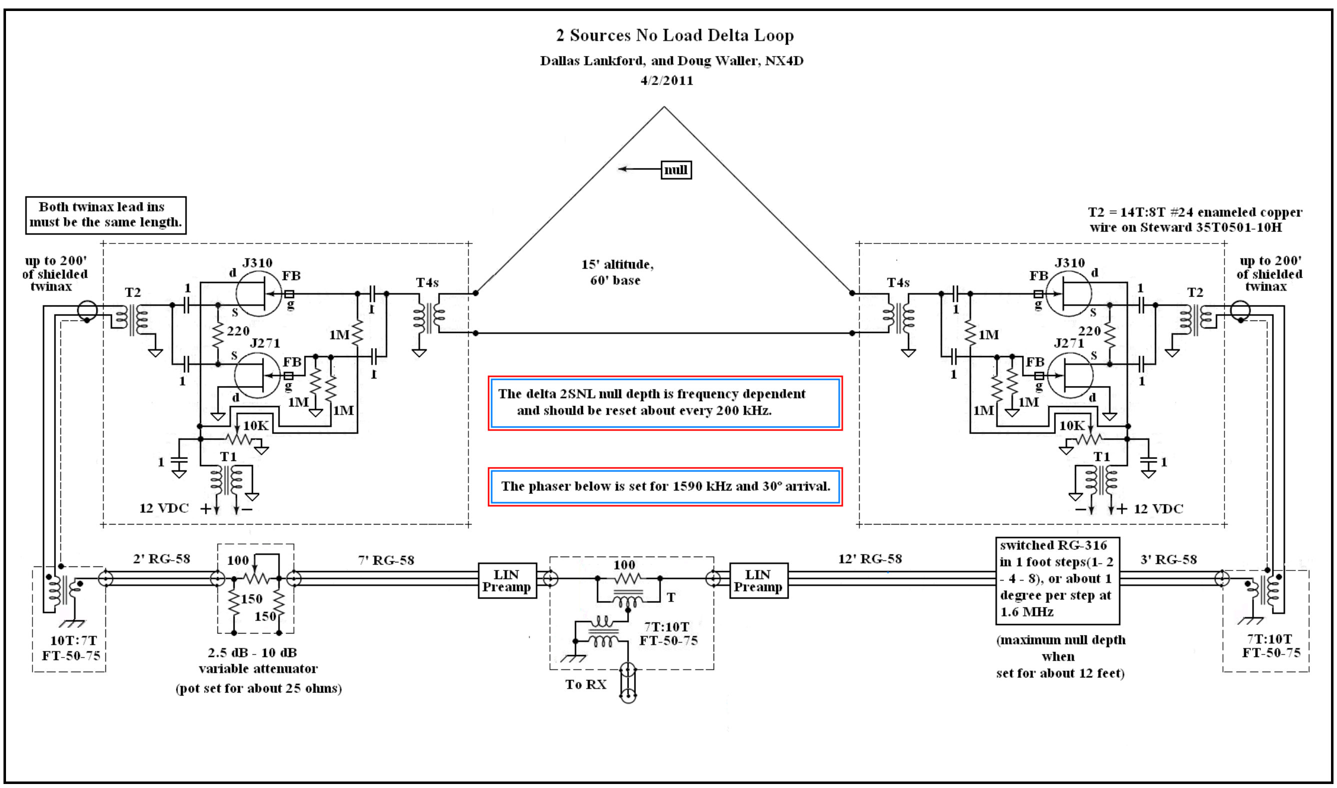
I implemented a single 2SNL delta loop with phasing for which EZNEC predicted a near-cardioid pattern and got... virtually no null, and no increase in gain compared to a standard delta flag of the same size.



The lack of gain increase was perhaps due to incorrect impedance matching. And the lack of null was perhaps due to the negative resistance of one of the sources. The fixed phaser predicted by EZNEC was replaced with a modified Misek variable phaser like the one at right (magnify it for better viewing if necessary). The nulls were excellent, and could be steered through 360 degrees. And with PPL's at the two antenna sources (which effectively solved the impedance matching issue), gain was excellent. Here was a single antenna which required only 60 feet of linear space with steerable nulls better than any of my previous dual vertical and dual inverted null steered arrays! At right is a schematic and diagram of the variable phaser 2SNL antenna. If you live in a very low noise location, a low noise 11 dB nominal gain push-pull Norton transformer feedback amplifier at the receiver might be beneficial. The two 24 turn bifilar transformers will probably not be necessary in many cases. They are 1:1 Guanella baluns which also function as common mode chokes. Various antenna transformers at both ends of the delta loop element were tried, but none of them improved the signal level output of the 2SNL. At right is a schematic of the modified Misek phaser. Other phasers may not give as good performance.



Although the 2SNL is an excellent null steered antenna, Doug wanted to use two of them as an improved (no resistor, so lower signal to thermal noise ratio) WF (dual rotatable top band array). This could perhaps be done, but the work required to build four modified Misek phasers would be prohibitive. What was wanted was a fixed phaser. So the trial and error method used in “Dual Active Vertical Arrays”was tried; see here . One good null on 580 kHz, Alexandria, LA, due South, was found quickly. But days passed before another null was generated at any other frequency. Finally (!) today (4/2/2011) a good null was generated on 1590 kHz, Fordyce, AR, due North. I had been barking up the wrong tree, adding delay to the delay predicted by EZNEC as I had done for the vertical array. The delay required for a good null at 1590 kHz was about 85% of the delay predicted by EZNEC. Furthermore, the fixed phase shifter for the vertical array seems to be broadband, suitable for nulling all frequencies from one end of the MW band to the other without changing any the phaser component values. But the



2SNL is a horse of another color; with a fixed phaser it is narrow band, unsuitable for a MW broadband array. But for a narrow band of frequencies, like top band, it should be excellent. Because of the narrow bandwidth, a 1.83 MHz transmitter, perhaps several miles away, will be needed to adjust the null for maximum depth for ground waves.

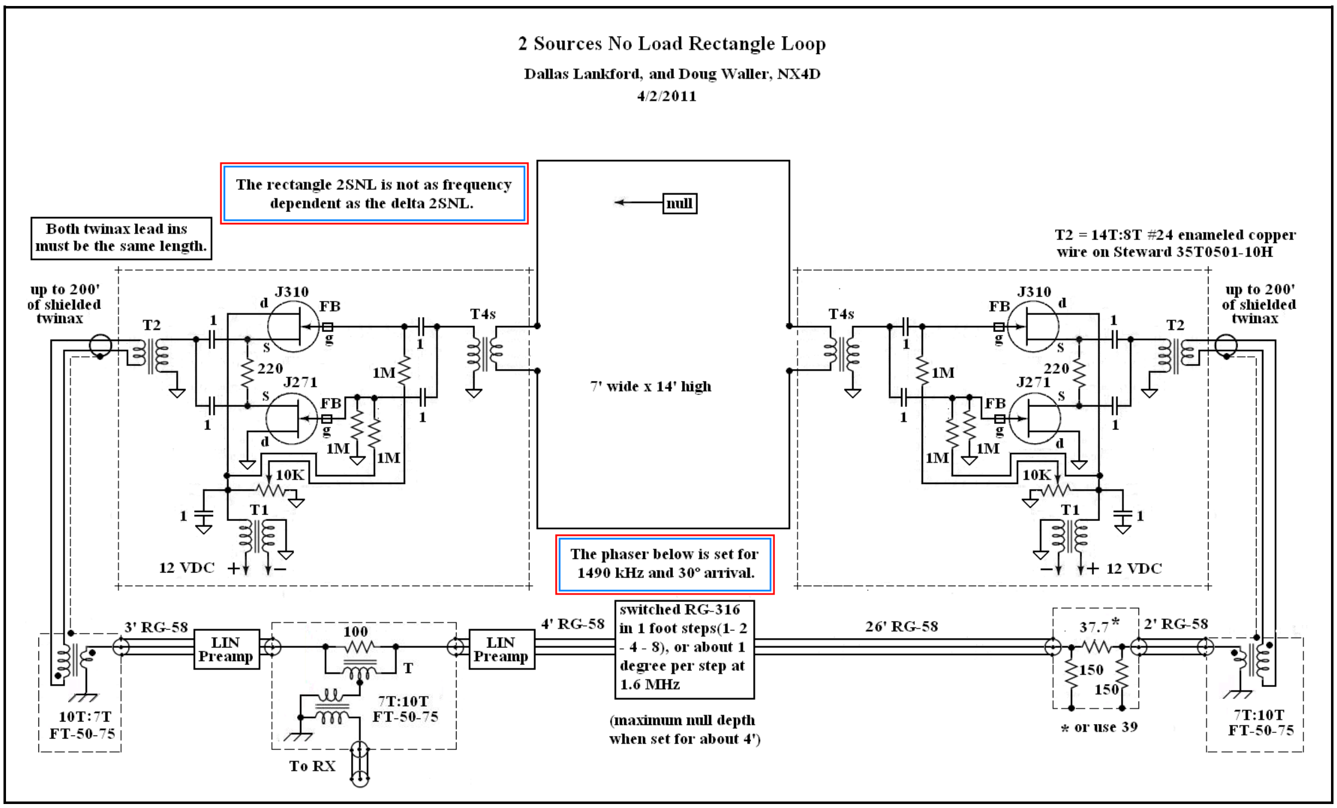
EZNEC simulation predicts that the pattern of a 2SNL is identical to the pattern of a flag. If this is so, and I believe it is based on observations of high MW band nulls, the it should be possible to make a dual 2SNL with the same pattern (and RDF) as a WF. And since the 2SNL contains no resistor, its thermal noise floor should be about 10 dB lower than a flag.

EZNEC simulation also predicts that a WF using two 2SNL antenna elements would have an RDF of 11.6 and about 26 dBi more than the original WF. That, of course, remains to be seen, but gain measurements at the top end of the MW band suggest that the gain improvement predicted by EZNEC is about right.

The schematic above shows exactly what was implemented and tested. The lengths of coax

and switched RG-316 can either be combined into a single 15' length of RG-316 (if you prefer coax), or a more compact and simpler LC delay.

For sky waves, multiply the ground wave phase by COS(θ) where θ is the desired arrival angle. Doug likes 24 degrees, and COS(24°) ≈ 0.9, so a13.5' length of RG-316 should be used instead of 15' for the final design. As sundown approached I swapped the 2' and 3' lengths of coax, which reduced the delay by 2'. Then I tuned around the top end of the MW band. 1510 kHz Nashville was hardly there until I disconnected one of the lead ins. Then it boomed in. Very good nulls were also observed on 1520 kHz Oklahoma City and 1530 kHz Cincinnati. Later after sunset transition had passed I tuned lower through the grave yard frequencies, eventually arriving at 1120 kHz St. Louis which was not nulled at all. Neither were any of the other clears below 1120 kHz. From this I concluded that when the 2SNL null was optimized on 1590 kHz, the null within ± 80 kHz was also excellent, but ± 470 kHz and greater there was no null. This demonstrates why the null of a top band 2SNL should be optimized at 1.83 MHz as stated above.

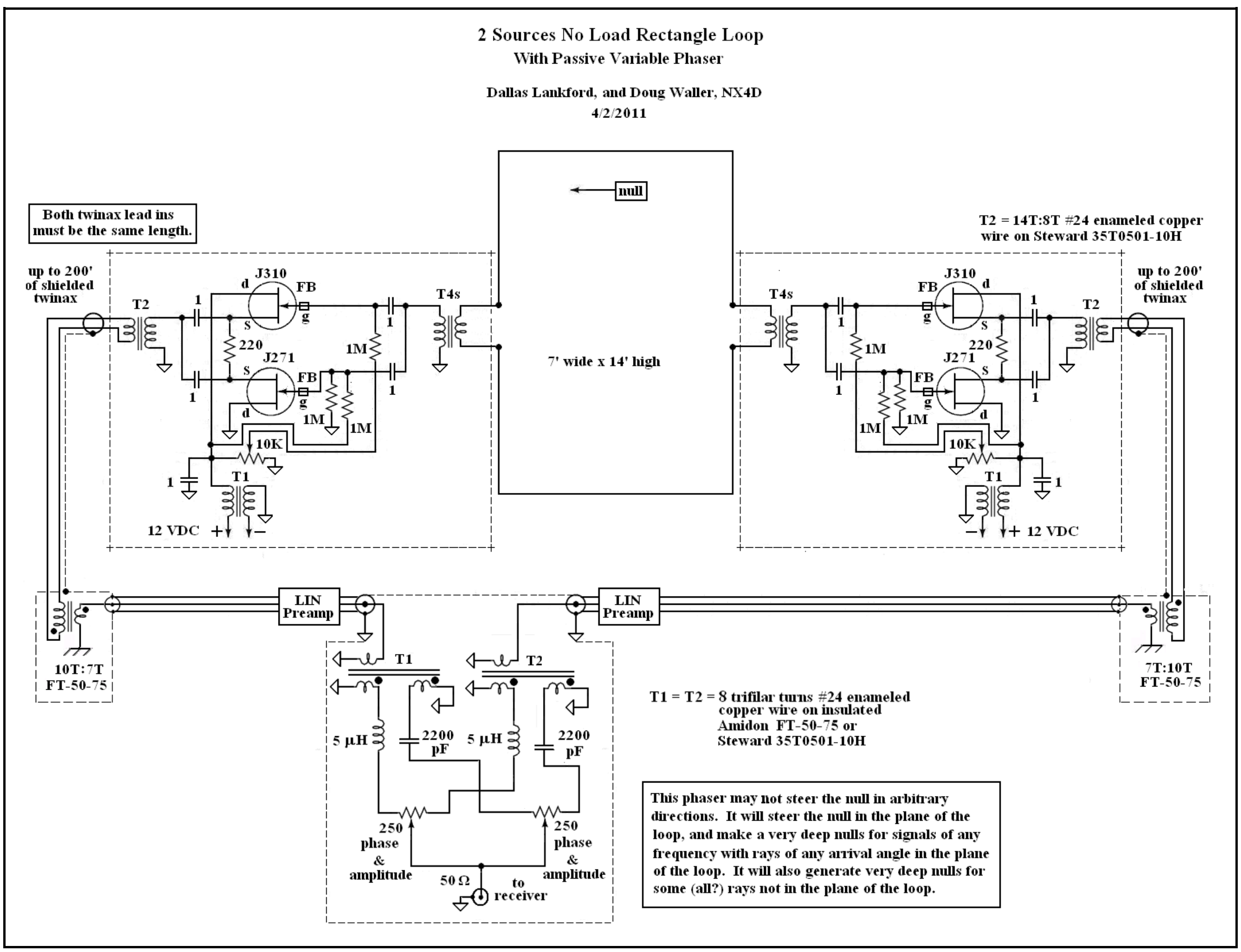


EZNEC simulation also predicts that the required phase for a single loop to form a “flag pattern” varies greatly, depending on the geometry of the antenna element and the feed points. To determine if this is in fact the case, a rectangle loop with 7' base and 14' height was implemented as shown in the schematic and diagram above.

For a 60' base and 15' altitude delta fed at the base corners, EZNEC predicted a phase lag of about – 49 degrees at 1.83 MHz. The measured lag was about – 43 degrees.

For a 7' base and 14' height rectangle, EZNEC predicted a phase lag of – 8 degrees. The measured lag was about – 215.5 degrees (note the 180 degree phase shift due to the transformer preceding the LIN preamp to the left of the combiner). Strictly speaking, neither of these is a lag because the delays they introduce are in the lead in path from the delayed antenna port. The rectangle 2SNL set up for 1490 kHz gives good nulls as low as 1120 kHz St. Louis, and "good –" (read good minus) nulls to as low as 890 kHz Chicago, as well as "average +" mulls on 780 and 720 kHz Chicago. 650 kHz Nashville had little or no null. Thus overall, the 7' base 14' height 2SNL rectangle gave a respectable showing. The pattern of dual 2SNL rectangle with center fed sides might be almost indistinguishable from a dual flag, but with a 10 dB lower thermal noise floor, and the pattern of a quad might be as good as a quad delta flag, but with a 10 dB lower noise floor.

Having said all of the above about fixed phaser versions of the 2SNL, it seems to me that the null depths of the fixed versions are not as deep as the null depths of the variable phaser version using a modified Misek phaser. I tried my much easier to build passive phaser, and it worked great for nulls in and near the plane of the 2SNL, which is all that is needed. Moreover, a simplified version of my passive phaser (sans some of the front end switching, and sans the two vernier phaser control pots worked equally well. So I have begun testing the simplified passive vernier phaser version. Strong thunder storms coming in from the West will delay thorough testing for at least 24 hours, but brief testing last night around midnight indicated that its nulls were superior to the fixed phaser 2SNL's discussed above. Below is a schematic of the passive phaser 2SNL.



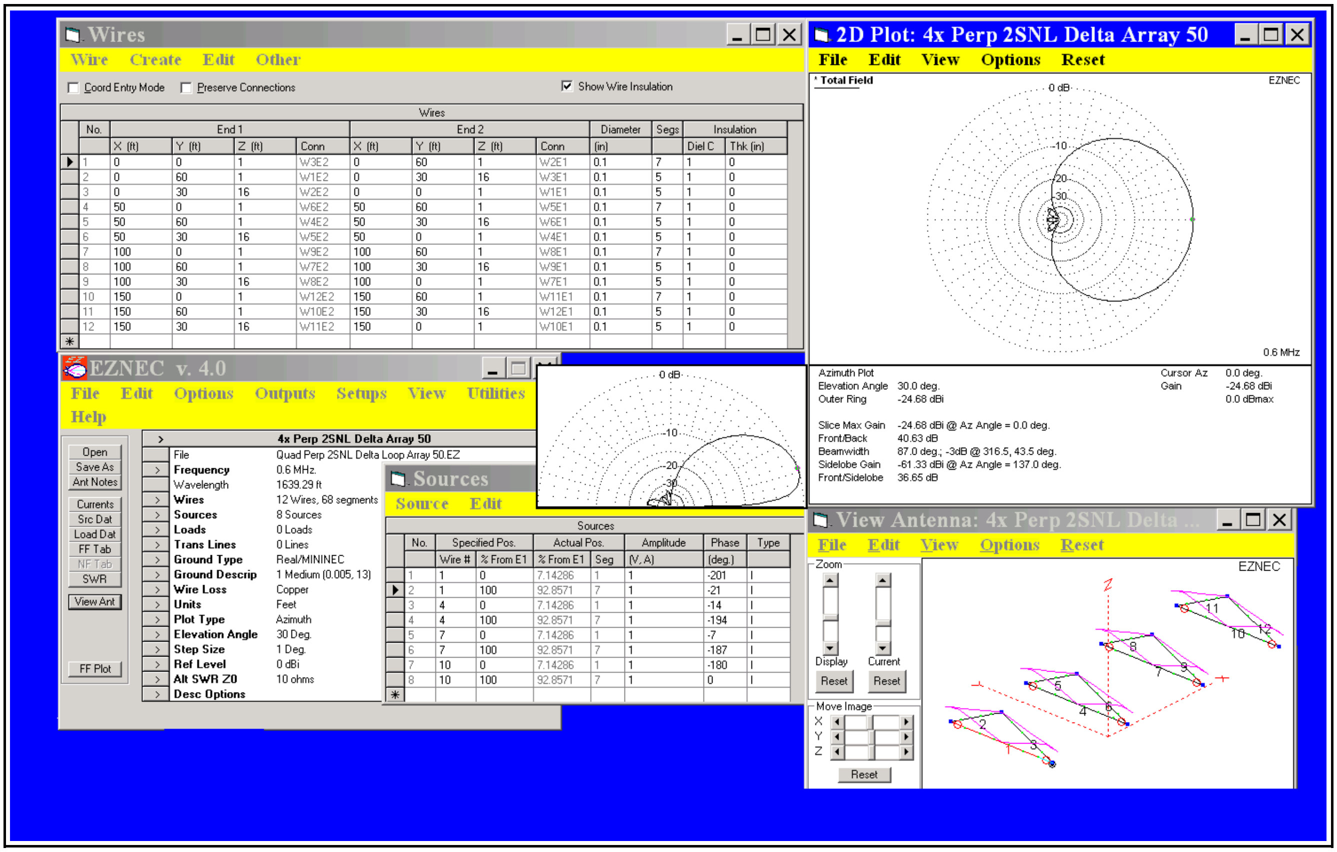
My passive phaser is constructed with expensive (if you buy them from Newark) 250 ohm (formerly) Allen Bradley Type J pots which are necessary if the phaser is used frequently as a null steered phaser. They are currently available for about $10 each from TEDSS here , although in what quantities I do not know. I have bought some of these myself, and they are excellent NOS Allen Bradley pots. It doesn't get any better than that. Honeywell currently sells Type J pots for about $40 each, but I do not know if they are as reliable as the older Allen Bradley Type J.

However, in this use the passive phaser is set once, and then not reset (or at worst reset infrequently). So it may be possible to use inexpensive 250 ohm pots instead, but I do not guarantee this. The Honeywell 53 Series and 380 Series which I tried many years ago became “scratchy” almost immediately. Multi-turn Cermet trimmers might work well, but I have not found any 5 turn trimmers except surface mounts. 200 ohm pots seem to work just as well as 250 ohm pots. If you don't want to wind transformers, MiniCircuits T-626 should work, see here . Sometimes Surplus Sales Of Nebraska prices are high, but in this case they are less than half MiniCircuits' list price. I wind high Q 5 µH inductors on suitable Amidon toroids Off the shelf reasonably high Q 4.7 µH inductors should be satisfactory.

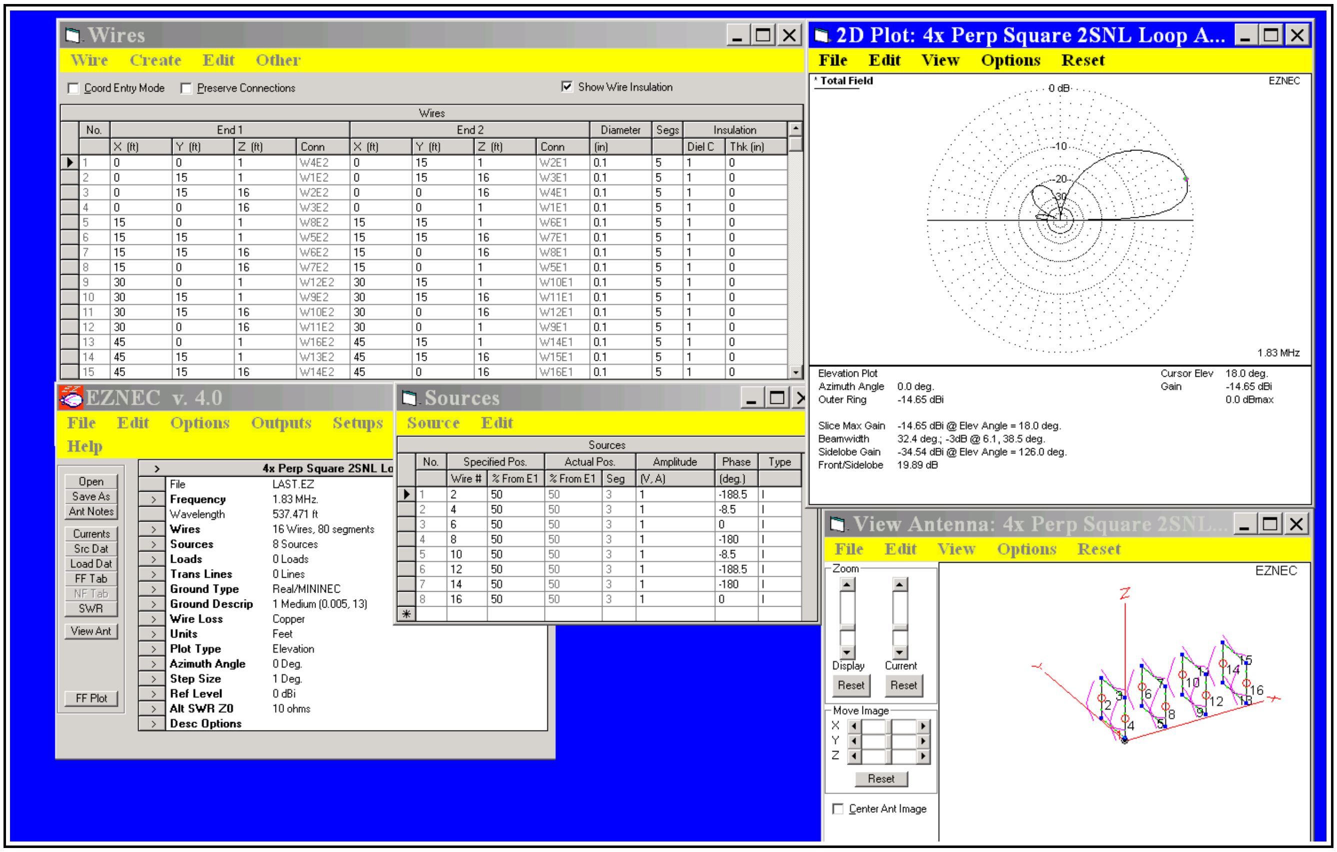
If you want to try this array for other frequencies or with other arrays, the schematic here is for the general 100 kHz – 30 MHz passive phaser which I use.

Testing of the variable passive phaser was completed the night of 4/5. Nulls generated with the passive phaser were no deeper than with the fixed coax phaser. The fixed coax phasers were merely much more tedious to adjust.

It appears that the 2SNL antenna elements can be used to design quad arrays which are more compact than the previous quad arrays, including the QDFA, QLA, PPL-QDFA, and PPL-QLA. The EZNEC simulation below is for a “perpendicular” 2SNL QLA. Each of the 2SNL elements is phased 180 degrees, which greatly simplifies their adjustments. The delays (phasings) between the front pair and rear pair, and between the front and rear pairs may not be accurate. We shall see (because I can implement this one in my side yard). The RDF of this perpendicular 2SNL quad array is about 11.5, considerably higher than than for previous QDFA and QLA arrays.



The graphic for a perpendicular 2SNL top band rotatable array with an RDF of about 12.5 according to EZNEC.


Wires
Wire Create Edit Other
Coord Entry Mode
Preserve Connections
Show Wire Insulation
Wires
No. End 1 End 2 Diameter Segs Insulation
X (ft) Y (ft) Z (ft) Conn X (ft) Y (ft) Z (ft) Conn (in) Diel C Thk (in)
1 0 0 1 W4E2 0 15 1 W2E1 0.1 5 1 0
2 0 15 1 W1E2 0 15 16 W3E1 0.1 5 1 0
3 0 15 16 W2E2 0 0 16 W4E1 0.1 5 1 0
4 0 0 16 W3E2 0 0 1 W1E1 0.1 5 1 0
5 15 0 1 W8E2 15 15 1 W6E1 0.1 5 1 0
6 15 15 1 W5E2 15 15 16 W7E1 0.1 5 1 0
7 15 15 16 W6E2 15 0 16 W8E1 0.1 5 1 0
8 15 0 16 W7E2 15 0 1 W5E1 0.1 5 1 0
9 30 0 1 W12E2 30 15 1 W10E1 0.1 5 1 0
10 30 15 1 W9E2 30 15 16 W11E1 0.1 5 1 0
11 30 15 16 W10E2 30 0 16 W12E1 0.1 5 1 0
12 30 0 16 W11E2 30 0 1 W9E1 0.1 5 1 0
13 45 0 1 W16E2 45 15 1 W14E1 0.1 5 1 0
14 45 15 1 W13E2 45 15 16 W15E1 0.1 5 1 0
15 45 15 16 W14E2 45 0 16 W16E1 0.1 5 1 0
2D Plot: 4x Perp Square 2SNL Loop A...
File Edit View Options Reset
Total Field
EZNEC
0 dB
-10
-20
-30
1.83 MHz
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring -14.65 dBi
Cursor Elev 18.0 deg.
Gain -14.65 dBi
0.0 dBmax
Slice Max Gain -14.65 dBi @ Elev Angle = 18.0 deg.
Beamwidth 32.4 deg.; -3dB @ 6.1, 38.5 deg.
Sidelobe Gain -34.54 dBi @ Elev Angle = 126.0 deg.
Front/Sidelobe 19.89 dB
EZNEC v. 4.0
File Edit Options Outputs Setups Help
Open
Save As
Ant Notes
Currents
Src Dat
Load Dat
FF Tab
NF Tab
SWR
View Ant
FF Plot
4x Perp Square 2SNL Lo
File LAST.EZ
Frequency 1.83 MHz.
Wavelength 537.471 ft
Wires 16 Wires, 80 segments
Sources 8 Sources
Loads 0 Loads
Trans Lines 0 Lines
Ground Type Real/MININEC
Ground Descrip 1 Medium (0.005, 13)
Wire Loss Copper
Units Feet
Plot Type Elevation
Azimuth Angle 0 Deg.
Step Size 1 Deg.
Ref Level 0 dBi
Alt SWR Z0 10 ohms
Desc Options
Sources
Source Edit
Sources
No. Specified Pos. Actual Pos. Amplitude Phase Type
Wire # % From E1 % From E1 Seg (V, A) (deg.)
1 2 50 50 3 1 -188.5 I
2 4 50 50 3 1 -8.5 I
3 6 50 50 3 1 0 I
4 8 50 50 3 1 -180 I
5 10 50 50 3 1 -8.5 I
6 12 50 50 3 1 -188.5 I
7 14 50 50 3 1 -180 I
8 16 50 50 3 1 0 I
View Antenna: 4x Perp Square 2SNL...
File Edit View Options Reset
Zoom
Display
Current
Reset
Reset
Move Image
X
Y
Z
Reset
Center Ant Image
EZNEC
Z