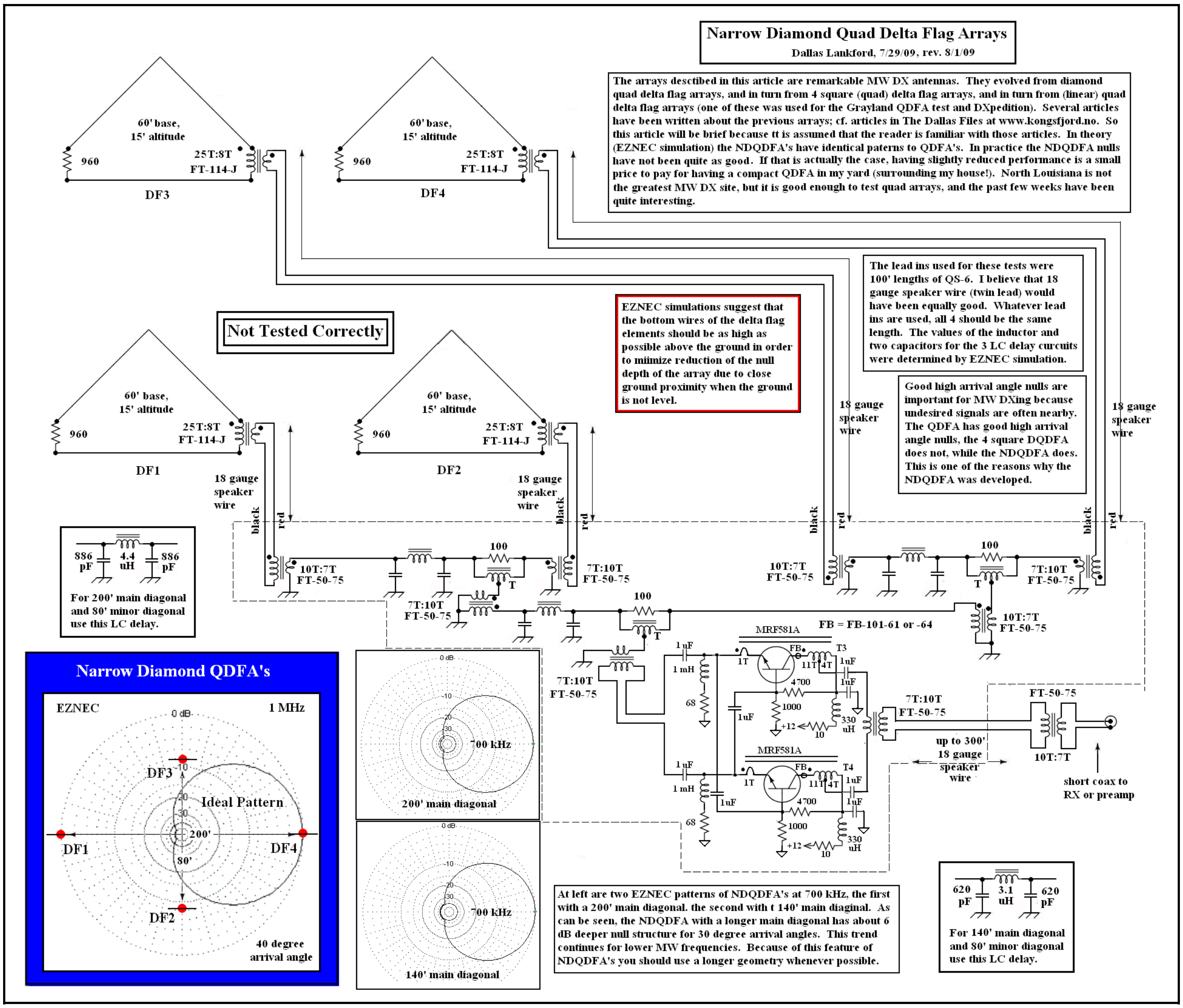
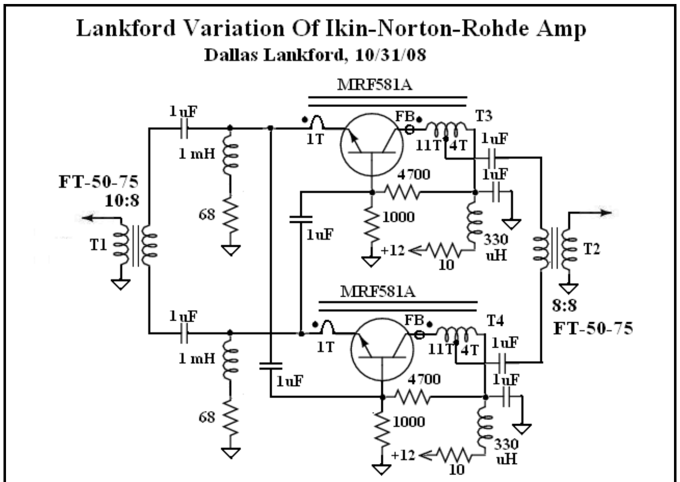
Narrow Diamond Quad Delta Flag Arrays

Dallas Lankford, 7/29/09, rev 10/4/09

Narrow diamond quad delta flag arrays were developed as compact quad delta flag arrays. To the best of my knowledge, narrow diamond quad delta flag (or flag) arrays have not been discussed or implemented before at any frequency. Narrow diamond quad delta flag arrays were inspired by W8JI's 4 square vertical arrays. Interestingly, the phasing of narrow diamond quad delta flag (or flag) arrays turned out to be identical to the phasing for the (linear) quad delta flag arrays I designed and used at Grayland (although, of course, the placement of the array elements is different), and identical to the phasing used by the W8JI 4 square vertical arrays (although the 4 square vertical arrays used coax delay lines and different combiners, while the narrow diamond arrays used discrete LC delays). Basic details of the narrow diamond quad delta flag arrays are given in the figure below. For better viewing the figure should be magnified. Additional details about delta flag and flag arrays are given in several articles in The Dallas Files , so the discussions in this article will necessarily be brief.



After implementing and testing the narrow diamond quad delta flag array I learned that the SP3KEY Team in Poland implemented a 4 square array of K9AY's in 2005. Their article seems to indicate that their implementation was for 40 and 80 meters only. No details of their phaser were given; presumably it was similar to the one developed by W8JI for the 4 square vertical arrays. Later I found an EZNEC pattern of a 4 square K9AY array which was given at the end of a long article about K9AY arrays where it was said that an array for 80 and 160 meters was operational in Poland. Those 4 square arrays were not narrow diamond arrays. According to EZNEC simulations quad arrays made from delta flag or flag elements are generally not as sensitive to geometry and phase perturbations as arrays made from other kinds of elements. Furthermore, as pointed out in the graphic above, according to EZNEC simulations square arrays generally do not have as good high arrival angle nulls and in some cases do not have as good nulls as narrow diamond quad delta flag arrays. EZNEC simulation has also shown that the deep null structures of 4 square delta flag, flag, and K9AY arrays are not as good as the corresponding deep null structures of corresponding narrow diamond arrays. If the EZNEC simulations are correct, it follows that narrow diamond quad delta flag or flag arrays are the best choices for compact narrow diamond quad MW arrays. Of course, flag arrays require more masts.



I converted one of my push-pull MRF581A Norton transformer feedback amplifiers to a variation of an Ikin-Norton-Rohde feedback amplifier by lifting the grounded ends of the 1 uF base bypass capacitors and connecting them to the opposite signal paths preceding the Norton emitter feedback links. My Norton amp was biassed for 16 mA per BJT, and this was not changed. The input and output transformers were MiniCircuits T1-6, the BJT transformers were wound on Amidon FT-50-75 (turns given on schematic). Before: IIP2 = +83 dBm, IIP3 = +36 dBm, gain = 10.3 dB. After: IIP2 = +80 dBm, IIP3 = +34 dBm, gain = 12.6 dB. Tones at 1.100 and 1.600 MHz, IMD2 at 0.500 MHz, IMD3 at 0.600 MHz.

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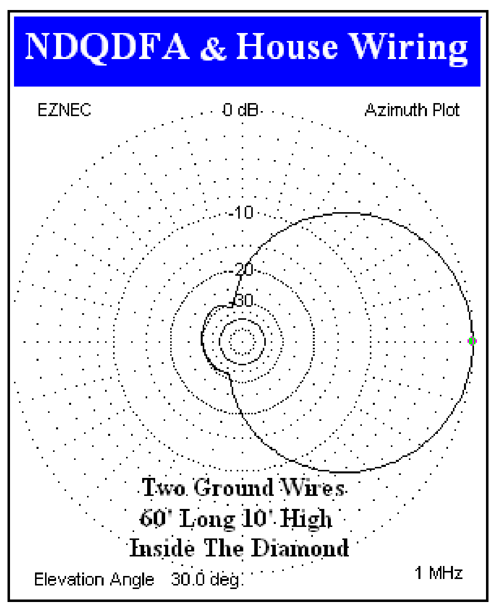
At right is a stand alone version of the LINR amp. Two of these, one included in the phaser as shown above, and one at the receiver, provide 25.2 dB gain as compared to 20.6 dB gain from two standard 11:4:1 Norton amps. The two LINR's may be sufficient to bring the low MW band signals back to an acceptable level for use with an insensitive receive like Perseus. Eventually this will be determined. The input and output impedances of the LINR at right are for 50 ohms. Appropriate changes of the turns ratios should be made for other impedances.

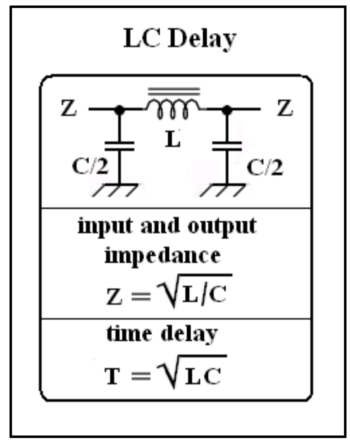
Tests

The NDQDFA became operational on 7/26/09. I used a NDQDFA with 140' main diagonal because a larger version will not fit on my lot. For low band nulls equal to the 100' (linear) QDFA, a main diagonal of 220' is required, and this is what I recommend for DXpeditions (if the array performance is verified). After several nights of testing it should have been obvious to me that the nulls of the NDQDFA were not as good as the nulls of a QDFA, but I was in denial. For many days I was baffled by this situation; now I am astonished that it took me so long to find a possible reasonable explanation. My house was in the center of the diamond array and that should have been a big hint. Of course, hindsight is always 20-20. I seem to recall previously simulating the array some additional wires in the middle of the array. But I did not use any grounded wires for those simulations. Anyway, when I finally simulated house ground wires for the narrow diamond delta flag array, EZNEC predicted that the resulting array pattern was significantly degraded as shown in the graphic at right. Well, sometimes you have to learn a lesson again the hard way. If a NDQDFA is implemented away from extraneous wires, especially grounded wires, then the array pattern ***may*** not depart from the ideal. However, ***other*** explanations for the less than ideal nulls observed during testing of the NDQDFA are possible, such as the close antenna element spacing inherent in the diamond array geometry. So it remains to be seen by appropriate testing whether the ideal NDQDFA pattern can be realized in practice.



LC Delay

The NDQDFA uses the same kind of LC phasing as the standard (linear) QDFA. The delay required from the front delta flag element (which will be denoted the maximum signal direction) to the rear delta flag element (which will be denoted the maximum null direction) is twice the delay required from the front delta flag element to the two middle delta flag elements. Furthermore, the two middle delta flag elements are also phase shifted 180 degrees. All of this can easily be seen from the schematic of the NDQDFA above. An NDQDFA with a given spacing and LC delay circuits can be changed to a square quad delta flag array or 4 square delta flag array merely by repositioning the middle elements. The null pattern of the 4 square delta flag array array is not as good as the null pattern of the NDQDFA. For best null, the length of the minor diagonal should be about 80/140 or 57% of the length of the major diagonal. The exact length of the minor diagonal should be determined by EZNEC simulation and varies somewhat with the size of the array. This assumes that EZNEC accurately simulates the patterns of 4 square and diamond arrays, which may or may not be the case.



The values of L and C are calculated as follows. The time delay T in nanoseconds along a ray with arrival angle α connecting two antennas with centers spaced a distance s apart in feet is T = 1.02 s COS(α) nS. For a 30 degree arrival angle and 70' spacing T = 62 nS. Previously this was converted into a length of coax to provide the necessary delay for phasing. The coax length has been replaced by the LC delay circuit at right, which resembles a low pass LC filter, and has been used in all of the delta flag arrays which I have developed. Its input and output impedances Z are the same. For a 50 ohm system, such as the dual, quad, and narrow diamond quad delta flag arrays, take Z = 50 which gives 2500 = L/C, or L = 2500 C. Taking T = 62 x 10^–9, which was calculated above, both sides of the time formula at right are squared, namely 3844 x 10^–18 = LC, after which substitution of 2500 C for L by the equation above gives 3844 x 10^–18 = 2500 C^2, or C = 1240 pF. Thus C/2 = 620 pF, and L = 2500 x 1240 x 10^–12 = 3.1 µH. The capacitors should be mica, and the inductor may be two parallel Miller 6.2 µH inductors, Mouser 542-4610-RG. Or use FT-50-61 toroids and an accurate inductance meter to make the required 3.1 µH inductors. L and C/2 values for other frequencies can be obtained by multiplying the values for 70' spacing by the ratio of the spacings. For example, for 100' spacing, L = (100/70) x 3.1 = 4.4 µH, and C/2 = 886 (820//68) pF mica capacitors. I used an inductance meter to wind 4.4 µH inductors on Amidon FT-50-61 ferrite toroids.