Rx antennas at IV3PRK: the TX3A DHDL

DOUBLING the Double Half-Delta Loop Receiving Antenna

by Pierluigi “Luis” Mansutti IV3PRK

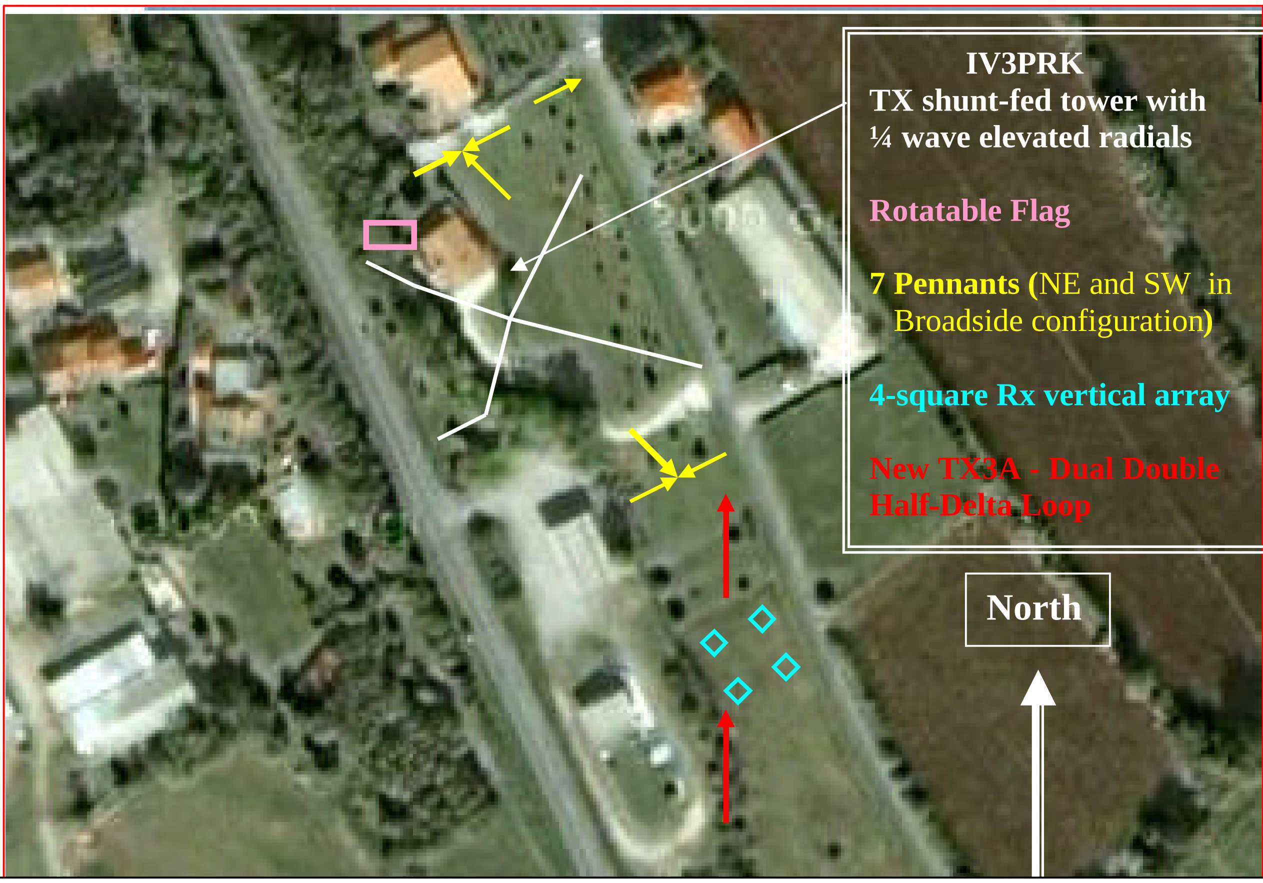
The design of this receiving antenna was originated by Jose Carlos, N4IS, who sent me the Eznec files, and George AA7JV, who used a single element on Chesterfield is. DXpedition and published for downloading from the TX3A web-site: http://tx3a.com/equipment.html

The basic design is essentially two half delta loops interconnected to create a single antenna, with one transformer and one load resistor, as well documented in the AA7JV paper. The innovative idea of connecting those loops at low level, without a long top wire, allows an easier and lighter construction.

I have been always fighting with noise and interactions, and tried every kind of RX antennas, within my constraints and limited space. I found that the best ones, i.e. more quiet, are still the Pennants, their best characteristic being the “ground independence”, i.e. no ground connection. So all my past experiences encouraged me to enter EZNEC and investigate on the best possible design which could fit on my property.

The RDF achievable with two of these arrays is above 12 dB, really impressive, and the gain is “only” – 27dB, which is double (or better to say, half the loss) of the -55 dB of the Waller Flag and thus less problems with common noise and preamplifier requirements.

With 74 meters of total length I could get the same results of a long Beverage into the North direction where my toughest and most needed Pacific DX area is located.



Google Satellite picture with all 160 m. antennas situation on November 2009

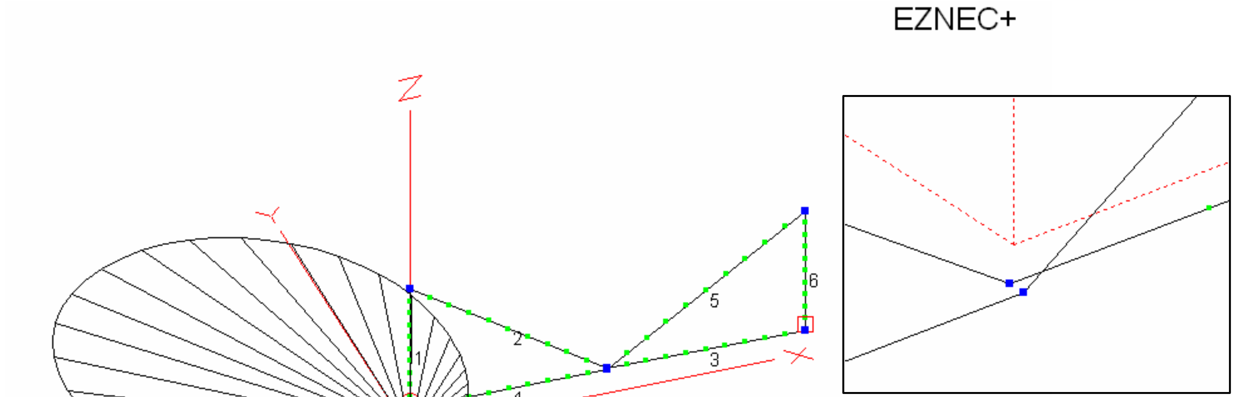
The following is a table showing the characteristics of the Pennant and Flag loop antennas as a result of Eznec 5+ modelling:

Model	Gain	TO angle	Beamwidth	F/B	Avg.gain	RDF	Source R.	Source X	Load R.
Flag standard	**- 29,97**	30	149	**30,0**	- 37,73	**7,76**	948	-6	950
Waller Flag	**- 56,09**	22	79	**27,0**	- 67,67	**11,58**			
Pennant standard	**- 35,50**	30	148	**32,4**	- 43,28	**7,78**	915	3	870
Pennants - Endfire	**- 32,35**	30	123	**56,0**	- 41,22	**8,87**			
Pennants - Broadside	**- 32,31**	30	55	**37,0**	- 43,32	**11,01**			
TX3A - Delta Double	**- 27,57**	20	106	**31,4**	- 37,52	**9,95**	806	-105	1200
TX3A- DUAL Delta Double	**- 26,77**	18	74	**31,0**	- 39,05	**12,28**			

The benefits of the TX3A designs are an improved RDF factor, with a low take-off angle and a good front to back ratio, while keeping the gain (loss) low enough to require only a normal preamplifier.

It's interesting to compare the above characteristics with those of many other RX antennas. See the very interesting page of my friend Lee, K7TJR: http://www.k7tjr.com/rx1comparison.htm .

As usual with antennas there is no free lunch, and these loop arrays require greater dimensions and can be only in a fixed direction; furthermore the beamwidth is pretty sharp and so not a wide compass area can be covered, but it can be a killer weapon in the target direction!



Particular: at mid point the wires cross each other but are not connected

As George said, there is nothing critical with this kind of loops and I investigated through Eznec models at the search of my optimum design. I began to change the load resistance value, because I didn't like that -105 ohms reactance appearing in the source data.

Model	Gain	TO angle	Beamwidth	F/B	Avg.gain	RDF	Load R.	Source R.	Source X
TX3A Delta Double	**- 27,64**	20	106	**26,7**	- 37,56	**9,92**	1150		
Height from 1,5 to 9 meters	**- 27,60**	20	106	**30,5**	- 37,53	**9,93**	1200	806	-105
Length 22 meters	**- 27,57**	20	106	**31,4**	- 37,52	**9,95**	1250	806	-105
	- 27,53	20	106	**29,2**	- 37,49	**9,96**	1300	806	-105
	- 27,50	20	106	**26,4**	- 37,46	**9,96**	1350		
	- 27,73	20	106	**17,7**	- 37,54	**9,81**	960	974	-1

Wide variations can be tolerated without differences in the RDF, just the F/B ratio is slightly peaking at 1.250 ohms. To get a purely resistive source data, the load should be reduced to 960 ohms, but at the expenses of the front to back ratio, which goes down below 18 dB, not acceptable.

My concern about the odd source data vanished after the insertion of a 12:1 transformer (one of the features of Eznec 5) and then a good match is achieved.

In the following table I summarise the results of Eznec runs with some dimensions variations:

Model variations	Gain	TO angle	Beamwidth	**F/B**	Avg.gain	**RDF**	Load R.
Shorted vert.wires 1 m.	- 29,16	20	105	**29,3**	- 39,11	**9,95**	1150
Height from 1,5 to 8 meters	- 29,12	20	104	**34,2**	- 39,10	**9,98**	1200
Length 22 meters	- 29,09	20	104	**33,7**	- 39,07	**9,98**	1250
	- 29,05	20	104	**29,2**	- 39,04	**9,99**	1300
Raised 0,50 m. (all)	- 29,24	20	104	**28,2**	- 39,26	**10,02**	1150
Height from 2 to 8,5 meters	- 29,21	20	104	**33,2**	- 39,24	**10,03**	1200
Length 22 meters	- 29,17	20	104	**35,1**	- 39,22	**10,05**	1250
	- 29,13	20	104	**30,6**	- 39,19	**10,06**	1300
Lenghted vert.wires 0,5 m.	- 28,47	20	105	**27,0**	- 38,46	**9,99**	1150
Height from 2 to 9 meters	- 28,43	20	105	**31,1**	- 38,45	**10,02**	1200
Length 22 meters	- 28,40	20	105	**33,5**	- 38,42	**10,02**	1250
	- 28,36	20	105	**30,7**	- 38,39	**10,03**	1300
	- 28,32	20	104	**27,2**	- 38,36	**10,04**	1350
Shorted 2 meters	- 30,62	20	104	**25,8**	- 40,65	**10,03**	1150
Height from 2 to 8,5 meters	- 30,59	20	104	**30,3**	- 40,64	**10,05**	1200
Length 20 meters	- 30,55	20	104	**38,1**	- 40,62	**10,07**	1250
	- 30,51	20	104	**38,5**	- 40,59	**10,08**	1300
	- 30,47	20	104	**31,0**	- 40,56	**10,09**	1350
Extended 4 meters	- 28,02	20	104	**26,3**	- 37,99	**9,97**	1100
Height from 2 to 8,5 meters	- 27,99	20	104	**30,5**	- 37,97	**9,98**	1150
Length 24 meters	- 27,95	20	104	**32,5**	- 37,95	**10,00**	1200
	- 27,91	20	104	**30,2**	- 37,92	**10,01**	1250
	- 27,88	20	104	**26,8**	- 37,88	**10,00**	1300
	- 27,84	20	104	**24,2**	- 37,84	**10,00**	1350
Lenghted vert.wires 1 m.	- 26,54	20	106	**24,5**	- 36,47	**9,93**	1100
Height from 2 to 9,5 meters	- 26,51	20	106	**27,4**	- 36,46	**9,95**	1150
Length 24 meters	- 26,48	20	106	**29,7**	- 36,44	**9,96**	1200
	- 26,44	20	105	**29,3**	- 36,41	**9,97**	1250
	- 26,40	20	105	**27,0**	- 36,37	**9,97**	1300
	- 26,36	20	105	**24,6**	- 36,34	**9,98**	1350

We see that the antenna wants to work whatsoever, so next I took into consideration the available supports and the best placement among my fruit trees. The physical beauty of this array is that everything is at about 2 m. height: loads and feeding boxes with the low connecting wire stretched between them without disturbing anybody. Furthermore the entire receiving loop is extending above the metallic fences.

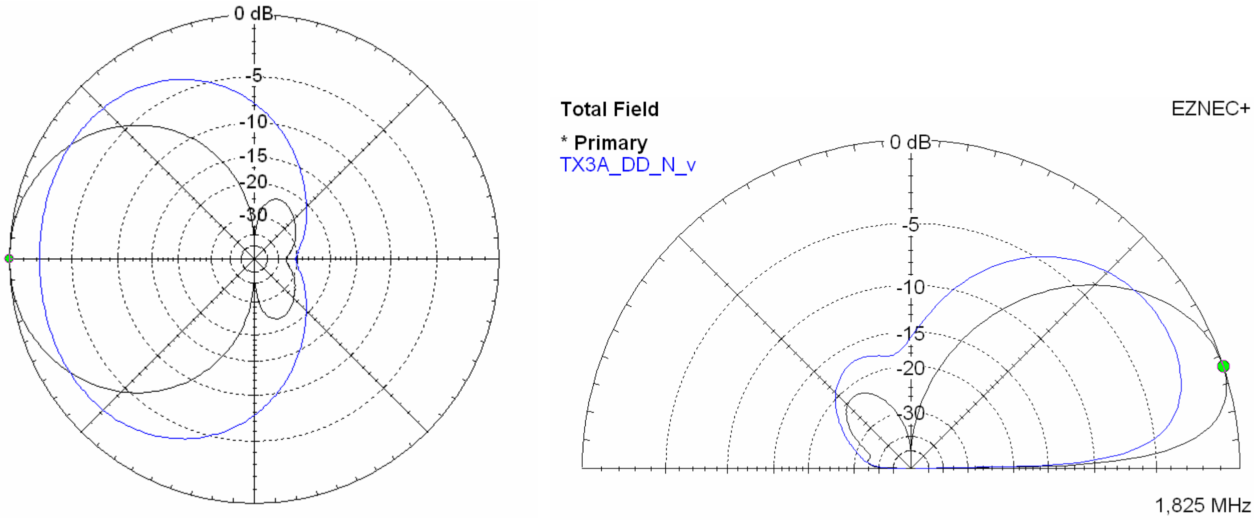
I bought four fiberglass fishing rods (7 m. long at 16.00 euro each) thin enough to support a very light 1 mm. aluminium wire (a cheap Japanese type sold in garden markets for bonsai use) and tied them on 2.5 m. wooden poles (used for trees support)

After choosing the dimensions of the loops I tried to find the best separation between them for end-fire configuration (with 180 degrees phase difference):

TX3A_DUAL Double Half Delta Loops	with 12:1 Xfmrs and 75 ohm T/L lines connected at a T junction to 50 ohm feedline							
Model variations	Gain	TO angle	Beamwidth	**F/B**	Avg.gain	**RDF**	Load R.	Feed Imp.
<u>N4IS/TX3A original design</u>	- 26,42	18	75	**27,6**	- 38,66	**12,24**	1.150	**39+j4**
Height from 1,5 to 9 meters	- 26,39	18	75	**31,0**	- 38,64	**12,25**	1.200	**41+j5**
Length loop 22 meters	- 26,35	18	75	**31,4**	- 38,61	**12,26**	1.250	**42+j7**
Separation 28 m.	- 26,32	18	75	**28,6**	- 38,58	**12,26**	1.300	**43+j7**
Total extension 72 m.	- 26,28	18	75	**25,8**	- 38,54	**12,26**	1.350	**41+j5**
<u>Shorted vert.wires 1 m.</u>	- 28,03	18	74	**29,2**	- 40,32	**12,29**	1.150	**40+j4**
Height from 2 to 8,5 meters	- 27,99	18	74	**34,7**	- 40,30	**12,31**	1.200	**41+j6**
Length loop 22 meters	- 27,96	18	74	**34,7**	- 40,27	**12,31**	1.250	**42+j7**
Separation 28 m.	- 27,92	18	74	**29,8**	- 40,23	**12,31**	1.300	**43+j7**
Total extension 72 m.	- 27,88	18	74	**26,2**	- 40,19	**12,31**	1.350	**41+j5**
<u>Reduced Sep. by 4 m.</u>	- 28,56	18	73	**29,2**	- 40,91	**12,35**	1.150	**40+j5**
Height from 2 to 8,5 meters	- 28,52	18	73	**34,6**	- 40,88	**12,36**	1.200	**41+j6**
Length loop 22 meters	- 28,49	18	73	**34,7**	- 40,85	**12,36**	1.250	**42+j7**
Separation 24 m.	- 28,45	18	73	**29,8**	- 40,82	**12,37**	1.300	**43+j7**
Total extension 68 m.	- 28,41	18	73	**26,2**	- 40,78	**12,37**	1.350	**41+j5**
<u>Extended Sep. by 8 m.</u>	- 27,57	18	75	**29,3**	- 39,80	**12,23**	1.150	**40+j5**
Height from 2 to 8,5 meters	- 27,54	18	75	**34,7**	- 39,78	**12,24**	1.200	**41+j6**
Length loop 22 meters	- 27,50	18	75	**34,9**	- 39,75	**12,25**	1.250	**42+j7**
Separation 32 m.	- 27,47	18	75	**29,7**	- 39,71	**12,24**	1.300	**43+j7**
Total extension 76 m.	- 27,43	18	75	**26,2**	- 39,68	**12,25**	1.350	**41+j5**
<u>IV3PRK final design</u>	- 27,79	18	74	**29,2**	- 40,05	**12,26**	1.150	**40+j4**
Height from 2 to 8,5 meters	- 27,76	18	74	**34,7**	- 40,03	**12,27**	1.200	**41+j6**
Length loop 22 meters	- 27,72	18	75	**34,9**	- 40,00	**12,28**	1.250	**42+j7**
Separation 30 m.	- 27,69	18	74	**29,8**	- 39,97	**12,28**	1.300	**43+j7**
Total extension 74 m.	- 27,65	18	74	**26,2**	- 39,93	**12,28**	1.350	**41+j5**

Again, very small differences for every kind of variations, with RDF going from 12.25 to 12.36 and F/B from 31 to 35 dB. So I choose the best separation to fit within my borders and the 4-square RX array.

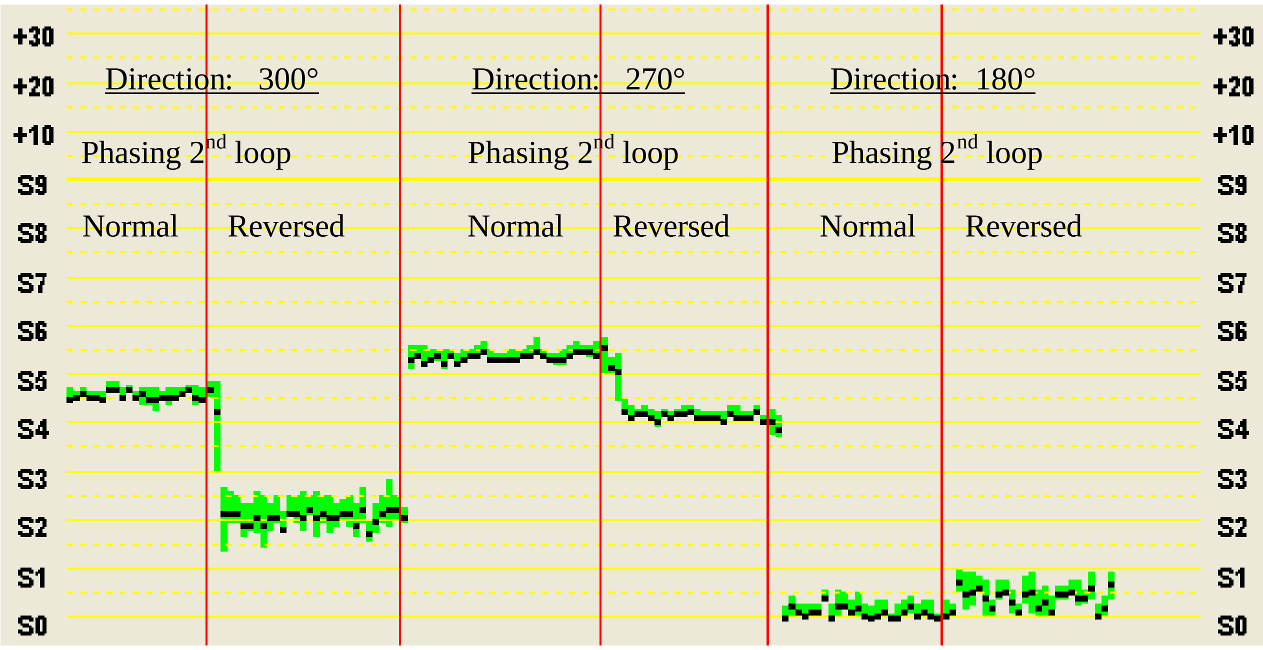
The transformers used are wound on binocular BN73-202. For 75 ohm cable I calculated 2 turns on the low side and 7 turns on the high side, but after installed I got a perfect match by removing one turn, Thus the final Xmfrs are both 2 turns on primary and 6 turns on secondary.



These are the azimuth and elevation beautiful plots (primary black traces) for correct phase reversing,. I added the recalled bleu traces for normal phasing, that is after inverting one of the feedlines connection, and we see that a broader pattern at higher angle results, which could be useful in some occasions.

So I put a couple of relays in the closest box containing the binocular transformer to provide an easy way to swap the feeding phase.

I performed some tests with a small 1.843 xtal oscillator in the near field of the array and they confirm the broader lobe without reversing the phase. It should be better to these tests with the spectrum analyzer of an SDR receiver, which records the oscillator signal and also the band noise.

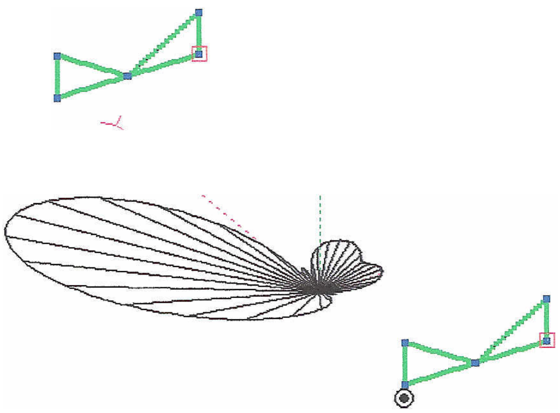


On the air tests of these first days are well promising despite propagation or activity from Central Pacific is not as good as it was some weeks ago. Europeans and Russians high angle signals are always better with the normal broad lobe position; the same with Japan, which is at 45 degrees. The only one I heard better on the reversed – best weapon position – has been Merv, KH7C, as it should be, straight through the North Pole at low angle.

But this path is exceptionally possible only at low solar minimum, without Aurora or any geomagnetic activity. Generally the signals are skewed East or West of the Polar Cap, so I'm afraid that such an array, in the North direction, will be useful only for a limited time at low solar cycle…

In any case it has been a positive new experiment with receiving antennas and the next one will be with a broadside configuration.

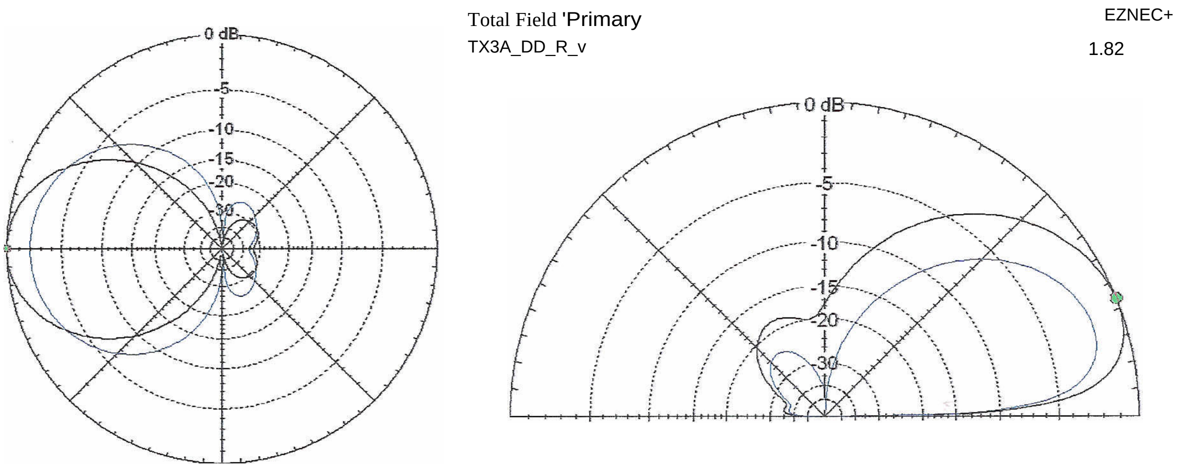
TX3A DHDL Double in Broadside



This will give an even better pattern than the end-fire, and an RDF reaching 13 dB with a separation of 100 meters between the loops. Unfortunately, while the elevation angle is higher with a broader lobe, the horizontal one is very sharp and in my particular situation it does not cover any needed direction. It could be placed only into 90 or 270 degrees, not enough for my most wanted area of the United States, between 300 and 335 degrees.

The table shows once again there is nothing critical : with wider distance the RDF improves and the lobe sharpens, but above 100 m. two secondary side lobes arise, worsening the pattern.

TX3A_DUAL Double Half Delta Loops	with 12:1 Xfmrs and 75 ohm T/L lines connected at a T junction to 50 ohm feedline							
Model variations	Gain	TO angle	Beamwidth	**F/B**	Avg.gain	**RDF**	Load R.	Feed Imp.
Broadside basic config.	- 25,92	22	52	**27,0**	- 38,58	**12,66**	1.150	**40+j5**
Height from 2 to 8,5 meters	- 25,89	22	52	**31,0**	- 38,56	**12,67**	1.200	**41+j5**
Length loop 22 meters	- 25,86	22	52	**32,8**	- 38,53	**12,67**	1.250	**42+j7**
Separation 90 m.	- 25,82	22	52	**30,3**	- 38,49	**12,67**	1.300	**43+j7**
	- 25,78	22	52	**27,0**	- 38,45	**12,67**	1.350	**41+j5**
Reduced Sep. by 10 meters	- 25,92	22	57	**27,0**	- 38,15	**12,23**	1.150	**40+j5**
Height from 2 to 8,5 meters	- 25,89	22	57	**31,0**	- 38,13	**12,24**	1.200	**41+j5**
Length loop 22 meters	- 25,86	22	57	**32,8**	- 38,10	**12,24**	1.250	**42+j7**
Separation 80 m.	- 25,82	22	57	**30,3**	- 38,07	**12,25**	1.300	**43+j7**
	- 25,78	22	57	**27,0**	- 38,03	**12,25**	1.350	**41+j5**
Extended Sep. by 10 meters	- 25,92	22	47	**27,0**	- 38,96	**13,04**	1.150	**40+j5**
Height from 2 to 8,5 meters	- 25,89	22	47	**31,0**	- 38,93	**13,04**	1.200	**41+j5**
Length loop 22 meters	- 25,86	22	47	**33,0**	- 38,91	**13,05**	1.250	**42+j7**
Separation 100 m.	- 25,82	22	47	**30,3**	- 38,87	**13,05**	1.300	**43+j7**
	- 25,78	22	47	**27,0**	- 38,83	**13,05**	1.350	**41+j5**
Extended Sep. by 20 meters	- 25,92	22	43	**27,0**	- 39,26	**13,34**	1.150	**43-j3**
Height from 2 to 8,5 meters	- 25,89	22	43	**31,0**	- 39,23	**13,34**	1.200	**44-j4**
Length loop 22 meters	- 25,85	22	43	**33,0**	- 39,20	**13,35**	1.250	**45-j5**
Separation 110 m.	- 25,82	22	43	**30,3**	- 39,17	**13,35**	1.300	**46-j7**
	- 25,78	22	43	**27,0**	- 39,13	**13,35**	1.350	**47-j8**



These are the azimuth and elevation plots of the broadside configuration at 90 m. separation (black primary traces) compared with previous end-fire ones at 30 m. separation (blue traces).

Anyway I never tried the broadside configuration in my limited lot, but I knew that Rys SP5EWY was building such an array in his second DX radio location and on January 27, 2010 he posted on the Topband Reflector the following comments:

Hi All,
Beeing inspired by an article written by Luis IV3PRK http://www.iv3prk.it/user/image/..-rxant.prk_tx3a.pdf (Thanks Luis!) I'v decided to build Double Delta Loop used by George on Chesterfield in a broadside configuration. Because of TX3D Australs DXpedition I'v made 250m Beverage in their direction and and just a week ago I'v built also this described Delta system.
I was trying both antennas in my second QTH 45 km from my house (its an orchard) yesterday but Deltas was not working and on Beverage TX3D was too weak. When I checked I discovered that one of wire in a delta was broken , so practically today was the first day I was able to compare antennas.
When I started to listening on Deltas in the first minutes I'v thought they are broken again because there was almost not any noise in a RX...but checking the band I'v found a lot of strong NA stations with very clean signals . I tested Deltas with the Beverage many times and always a difference was huge. Even a strength of stations was about 2S better on the Beverage the difference in the level of noise was not comparable...it was like day and night.
Using the Beverage I haven't heard even a trace of TX3D....on Deltas I'v heard them about 20 minutes ....but with deep QSB. 73 Rys SP5EWY

These are further building details Rys sent me.

The distance between Deltas is about 95m. Resistors are 1250 ohm , tranformers 12:1 bifilar windings ,2 pieces of coax 75 ohm each one 50m connected together to transformer 2:1 and to 75 ohm coax. I used similar fishing bats...8m high but I removed the last thinest part , so they are 7,1 m high attached to 2m high steel elements. The wire is 0,7mm CU.
TX3D was my #301 so I'm really VERY glad!

This is a picture of SP5EWY second low-band DX location showing one of the TX3A DHDL elements and the ¼ wave TX vertical. The environment is quite different from mine…but now I am sure that the design works OK!

January 28, 2010 Luis IV3PRK