Rx antennas at IV3PRK: the 4-Square Rx Vertical Array

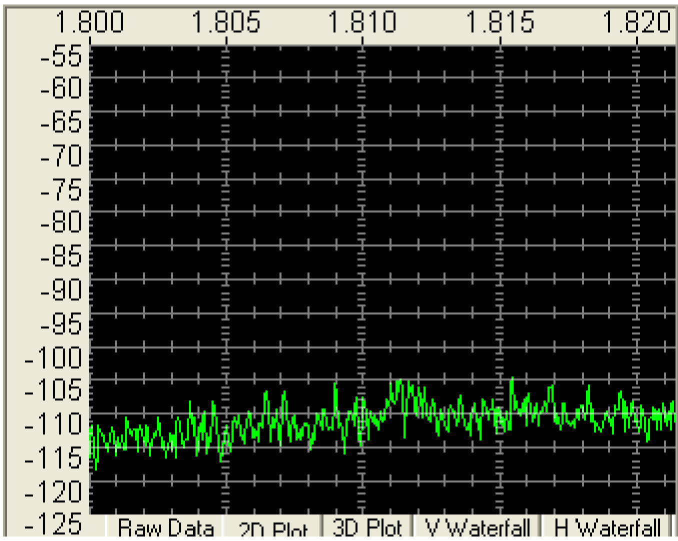
Part 6: From the homebuilt array to the K7TJR 4-square array with Hi-Z amplifiers

by Pierluigi “Luis” Mansutti IV3PRK

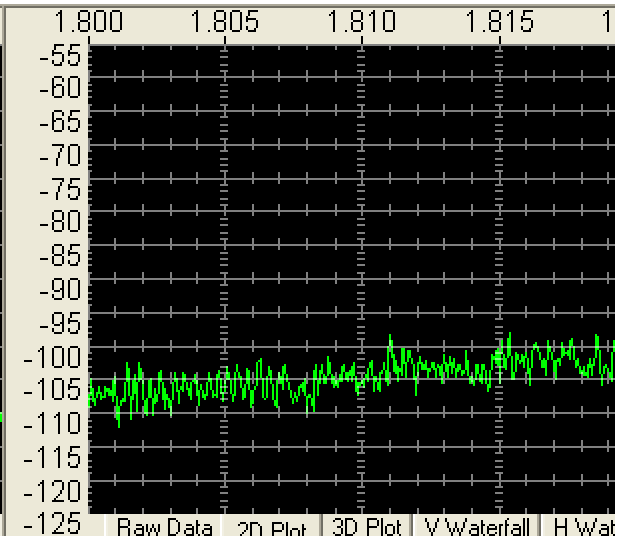
My 4-square Rx array is working very well, with a F/B of 30 dB, but it never outperformed the Pennants system where the S/N is always better on the weak DX signals.

The issue could have been in the particular lot where the 4-square is located, surrounded by very close power and telephone lines, or in the array stuff itself. So in a sunny dry afternoon I repeated once again the noise readings on the SDR-IQ receiver of all my receiving antennas, without any preamplifier. The following are two of the screen graphics taken in all the 8 switchable directions, the less noisy and the most noisy. The noise level on the Pennants is around -120 dBm.

4 square RX – dir. SW (best): - 110 dBm

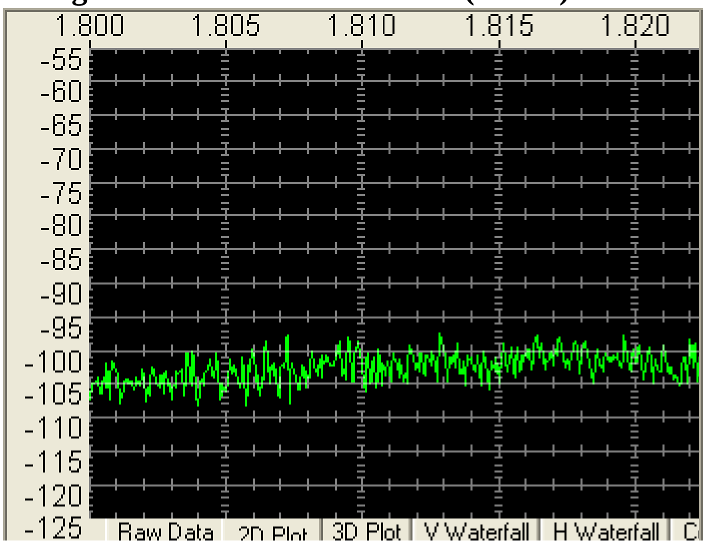


dir. NW (worst) – 103 dBm

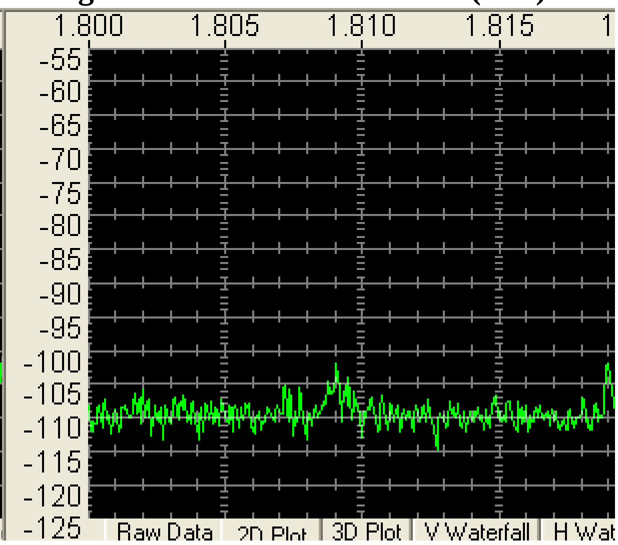


Then I connected the 75 ohm feedline directly to the single vertical elements in order to find which is the worst among them:

Single Ant. N.2 NW: -103dBm (Worst)

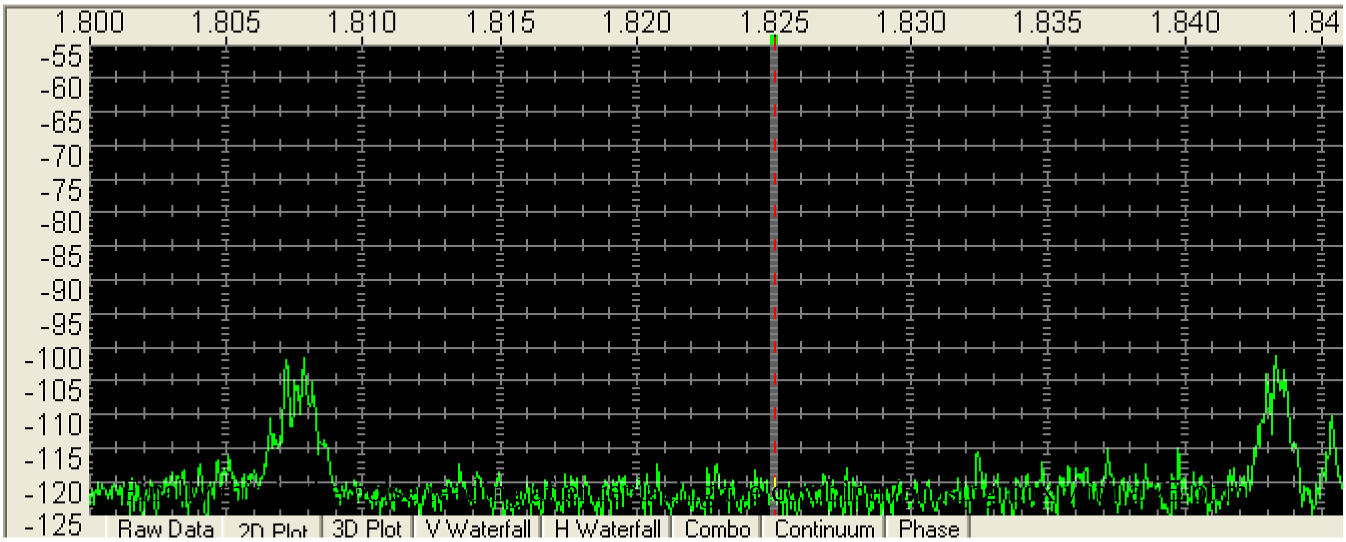


Single Ant. N. 3 SE: -110dBm (best)



Then I connected all the 4 feeding lines to 75 ohm resistors, replacing the antenna loads:

4 square RX – substituted vertical antennas with 4 x 75 ohm resistors : - 122 dBm

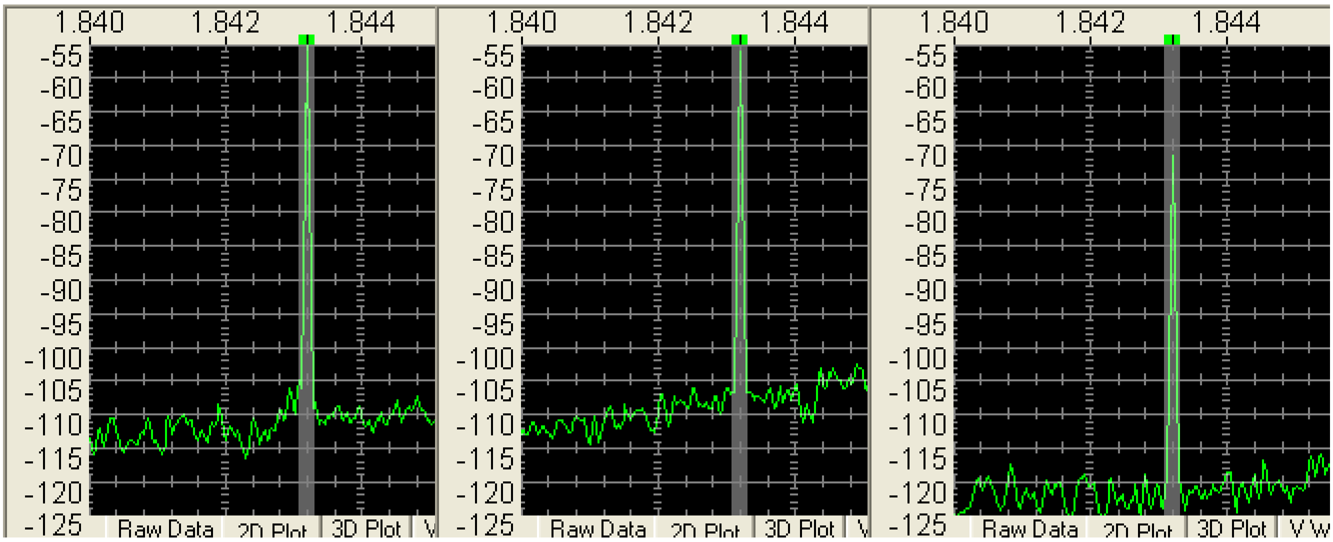


The picture is exactly the same at the feeding points of all the four elements and also on the output cable loaded with a 75 ohm resistor. So we must guess that the combiner, phasing circuit and feeding lines are working correctly: ALL THE NOISE is originated in the antenna elements.

At this point I guessed the problem could be in the loading wires of the vertical elements and/or the expanded ground system. I put again at almost one wavelength the 1.843 test oscillator and began to modify the 4-square elements.

For each element I took the SDR reading after disconnecting it from the radial system, and than after cutting the 4 foot tip with the loading wires (so the element length has been reduced to 6.33 meters). The following is one of the sequence, but all the others are almost the same.

Vert.3: A) Original **B) disconnected from radials** **C) cut the loading wires + 4 feet**



I took again the readings also on all the other antennas (Pennants, Flag and TX ant.) to compare with and the results seemed quite satisfying:

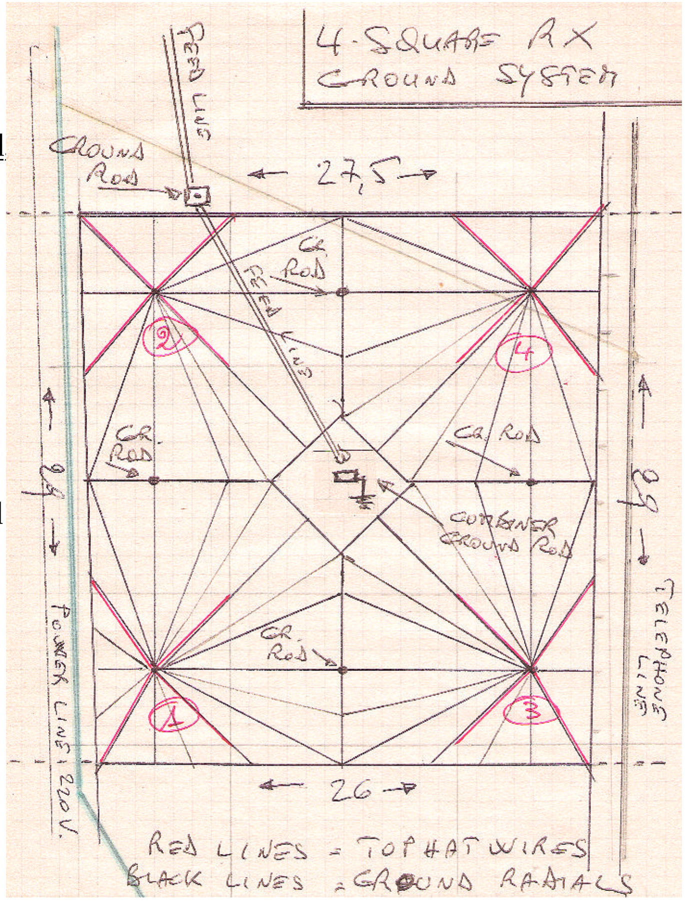
- the signal received on the shorted vertical elements, not yet matched to the 75 ohm impedance and much further from the test oscillator, were stronger than on the best Pennant
- the noise level has been reduced by 10 to 15 dB to the level of the quiet Pennants.
- the impedance had not yet been matched to the 75 ohms feedline and there was some room for improvement in order to get a good pattern in a 4 square phased array.

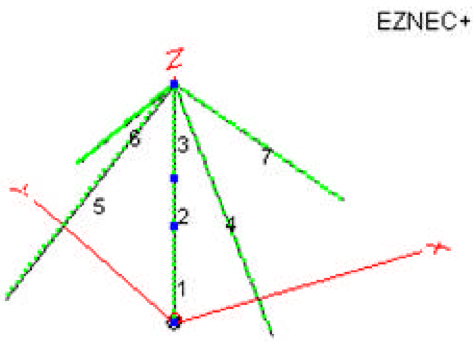
The wrong conclusion

It has been proved that a well designed and carefully built 4-square Rx array, with the W8JI top loading elements technique , does not work as expected within the constraints of my noisy lot.

A nice Front to Back of 30 dB was achieved thanks to carefully attenuators tuning (see the Rx 4-square.part 4 and Rx Ant. Tests PDF files), but only on strong signals …no way to pull out of the noise the weak DX, which is always better on the Pennants!

The loading wires and the elaborate ground system (see here on side) did a good job for stable impedance matching and correct phasing, but my wrong conclusion was that they were responsible of the a huge NOISE PICK-UP. Therefore I decided that this system was unfit in my environment with surrounding power and telephone lines.





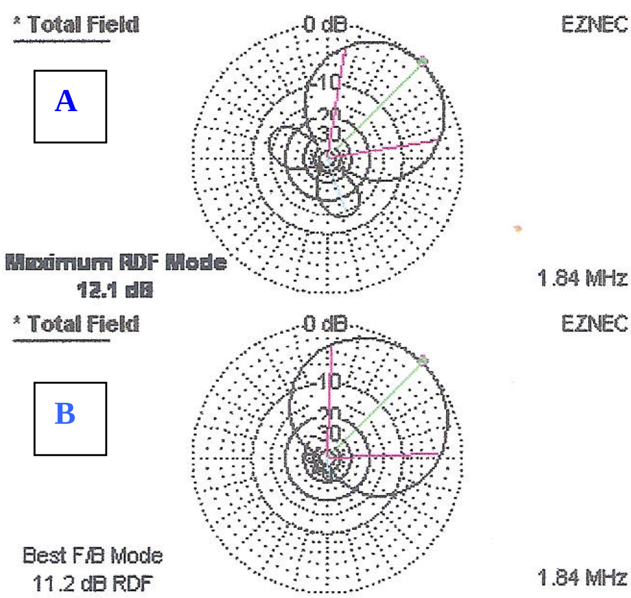
Now back to EZNEC to find the impedance of the simple vertical after removing the loading wires: R = 0,55 – jX 1214 ohms. With such an increase, the inductance required for a stable matching is more difficult to deal with the old classic stuff, so the best solution could have been to change the array to active antennas through the Hi-Z amplifiers.

The K7TJR 4-square receiving array

In over 40 years of DX activity I did never buy any antenna stuff, but working with small electronic circuits is beyond my technical capabilities, so I decided to test the 4-sq. array by K7TJR with his Hi-Z amplifiers.

Lee is a good friend with a long years experience in low bands receiving techniques; lately his production grew up a lot. On his great website http://www.hizantennas.com you can find all the stuff needed for Rx phased arrays at the cheapest prices of the market!

Most important, Lee is always helpful and his technical documentation is very useful to understand how the system works and to make the right decisions, on the personal needs.

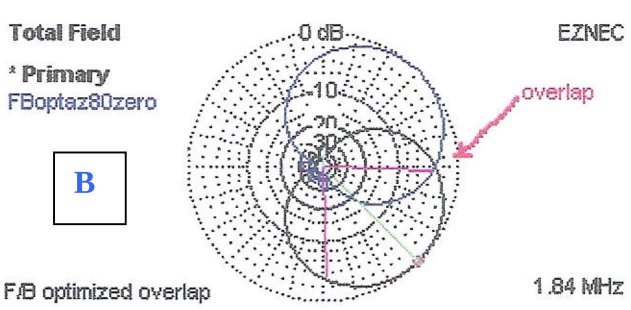


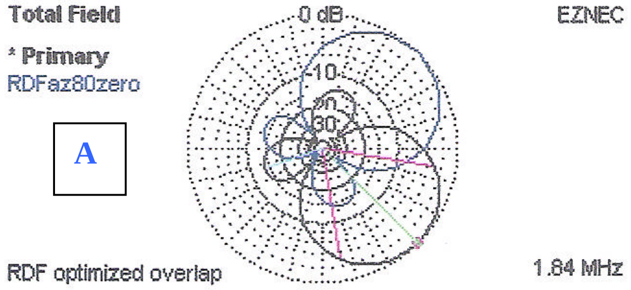
So the first decision is to choose between an array optimized for maximum RDF (Receiving Directivity Factor) mode “A” or the best Front to Back ratio mode “B”.

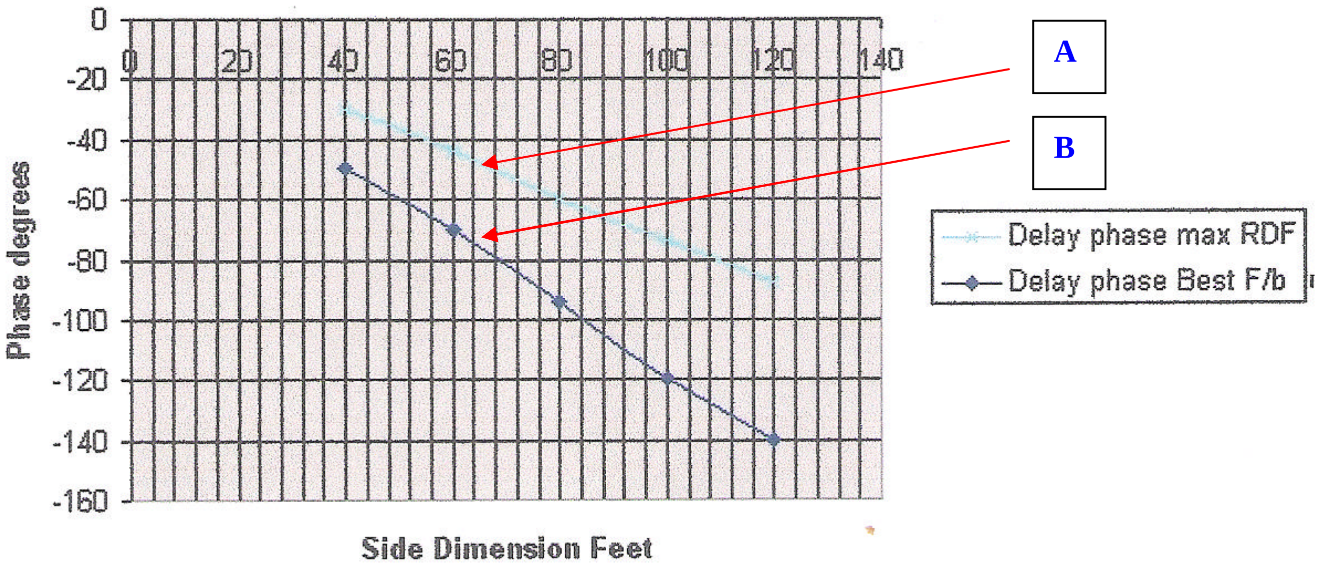
In the mode “A” you have a sharper lobe with a RDF of 12 dB, but two side lobes, while on “B” the lobe is broader, but with a better back null.

But these plots are for an array of at least 80 feet on a side in a clean open space free of fences, power lines or nearby metallic poles…. which is NOT my situation (more on this later).

The operation mode depends only by the length of the two delay lines. Full instructions are given on the calculating procedure, with the aid of the following graph.







So in my case, with a 20 meter side dimensions (67 feet), the longest delay line should be about 48 degrees, for max RDF, and about 72 degrees for best F/B. In practice the phasing is not critical, every value in between will work, provided the ratio between the two delay lines is kept exactly to 0.5 (less the corrections indicated in the instructions) and they are cut from the same roll.

I used what I had and so for mode A I kept the delay lines of my previous array corresponding to the phasing of 56/28 degrees. I wanted to try also the mode B and from the RG6 cable left I could cut two lengths of 25.97 + 12.05 m., corresponding to the phasing of 70/35 deg.

In the mean time my municipality came ahead also with the public lighting and so a new metallic pole has been added at a 20 ft. distance from a 4-sq. element : for sure it will not help !

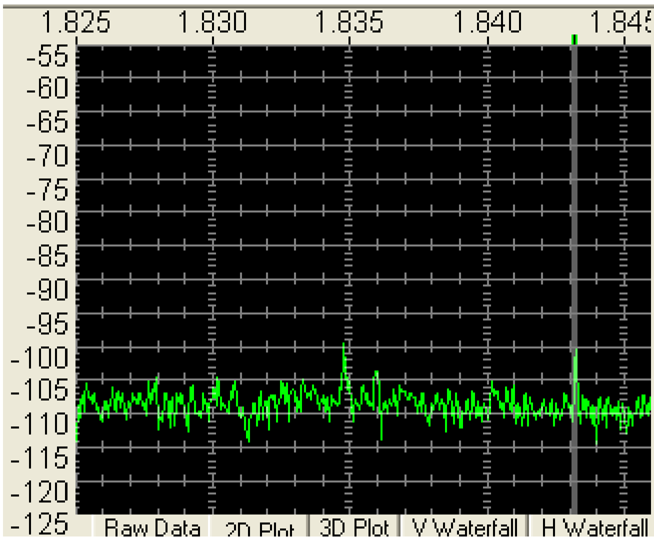
4-square array tests with a 1.843 oscillator

The following are the graphics printouts from the SDR-IQ receiver. The test oscillator set-up was put at about 300 meter distance from the 4-square array in the North East direction without any preamplifier.

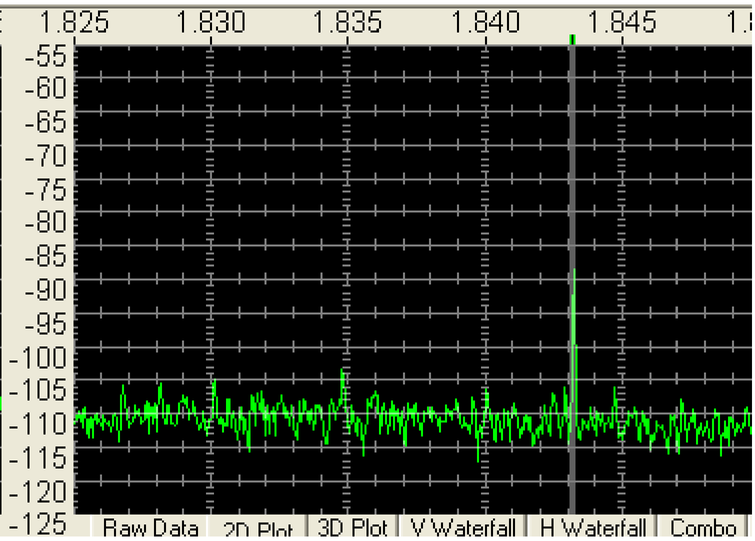
The delay lines were made with 75 ohm cable (similar to RG6) following Lee's instructions.
Case A (for Max. RDF) = phasing of 56 deg.:

- Long delay line corrected (56-1) to 55 deg. at 1.8 MHz x VF 0.82 = m. 20.70
- Short delay line corrected (28-3) to 25 deg. at 1.8 MHz x VF 0.82 = m. 9.40

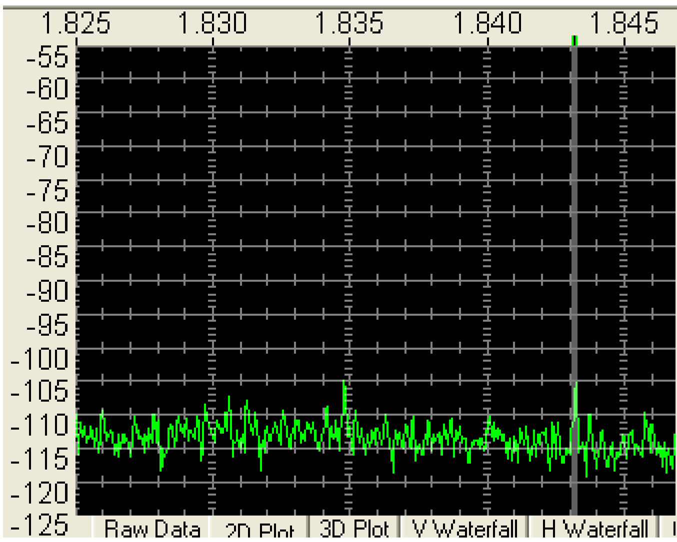
Case A - dir. NW: -100 dBm



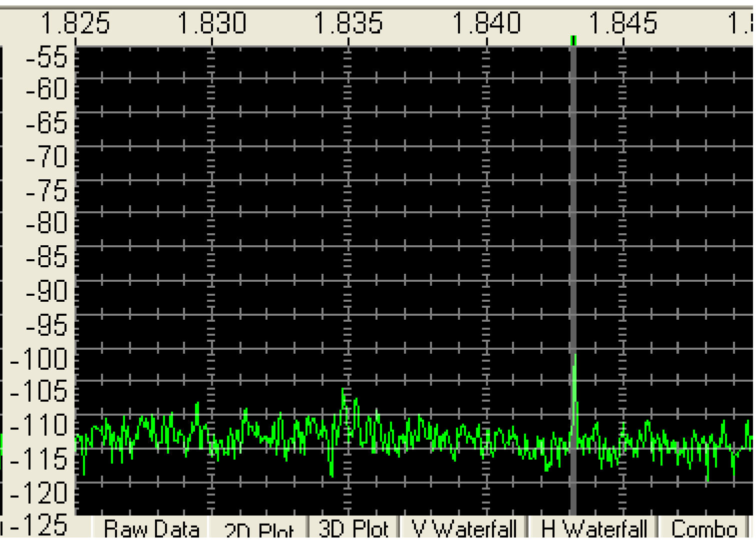
Case A – dir. NE: - 88 dBm



Case A – dir. SW: - 106 dBm



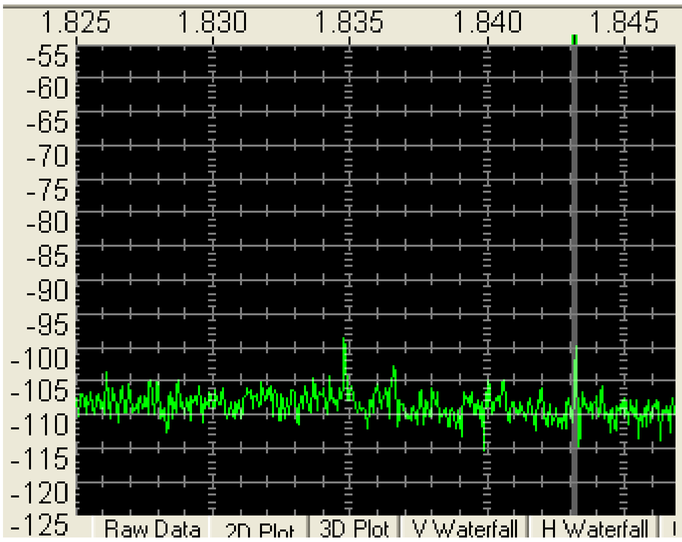
Case A – dir. SE: - 101 dBm



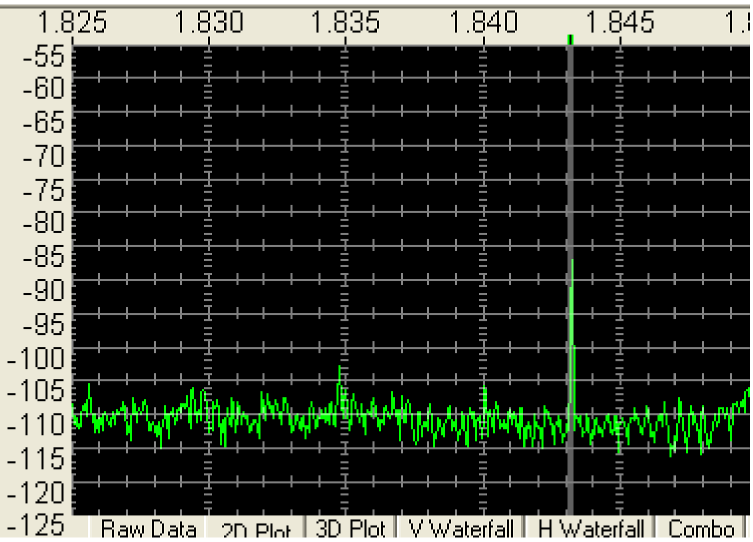
Case B (for best F/B) = phasing of 70.4 deg. (just as the max length from my cable left):

- Long delay line corrected (70.4-1) to 69.4 deg. at 1.83 MHz x VF 0.82 = m. 25.90
- Short delay line corrected (35.2-3) to 32.2 deg. at 1.83 MHz x VF 0.82 = m. 12.02

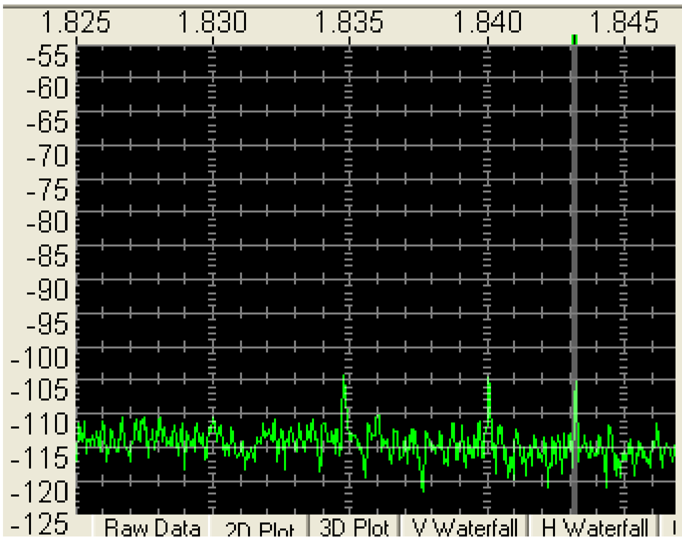
Case B – dir. NW: - 100 dBm



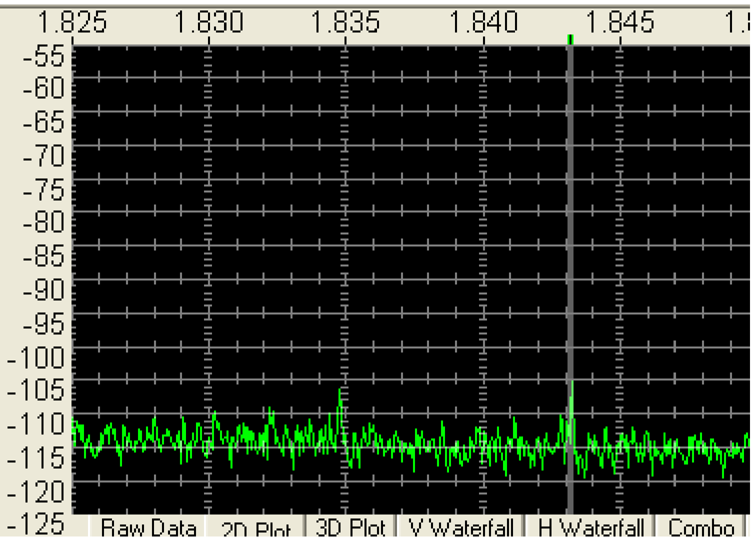
Case B – dir. NE: - 87 dBm



Case B – dir. SW: - 107 dBm



Case B – dir. SE: -105 dBm



Summarizing the results:

Case A			Case B	
		Down from front dir.		Down from front dir.
Dir. NW	- 100 dBm	12 dB	- 100 dBm	13 dB
Dir. NE	- 88	front direction	- 87	front direction
Dir. SE	- 101	13 dB	- 105	18 dB
Dir. SW	- 106	18 dB F/B	- 107	20 dB F/B

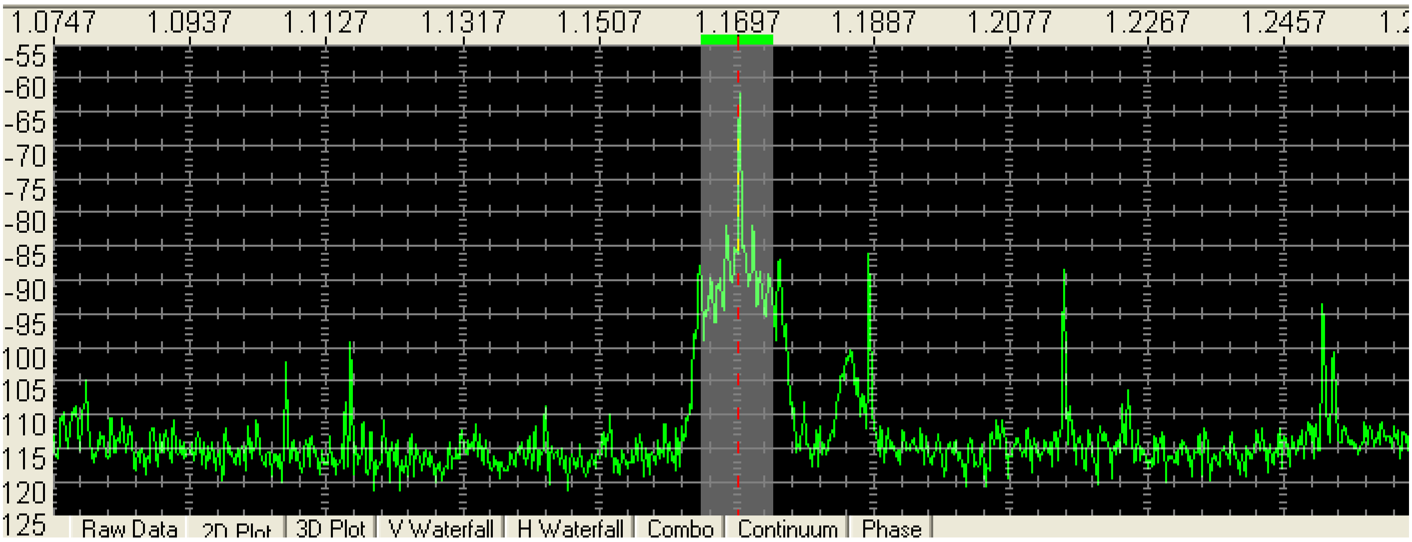
The RDF, supposed to be 12 dB in case A and 11 dB in case B, can only be computed in the EZNEC models but not measured in the realty.

The array is working well, as it should, with a neat lobe only in the forward direction and a good Front to Back of 20 dB. Not a great difference between the two phasing modes I used, so it's not critical and the array "wants to work easily". Anyway the F/B is not as high as with my previous homebuilt array, where 30 dB were achieved by carefully adjusting two T-attenuators inserted on the delay lines. But that was a single band array, tuned on 1.830 MHz, while this K7TJR 4-square is designed to operate from MW up to 40 meters.

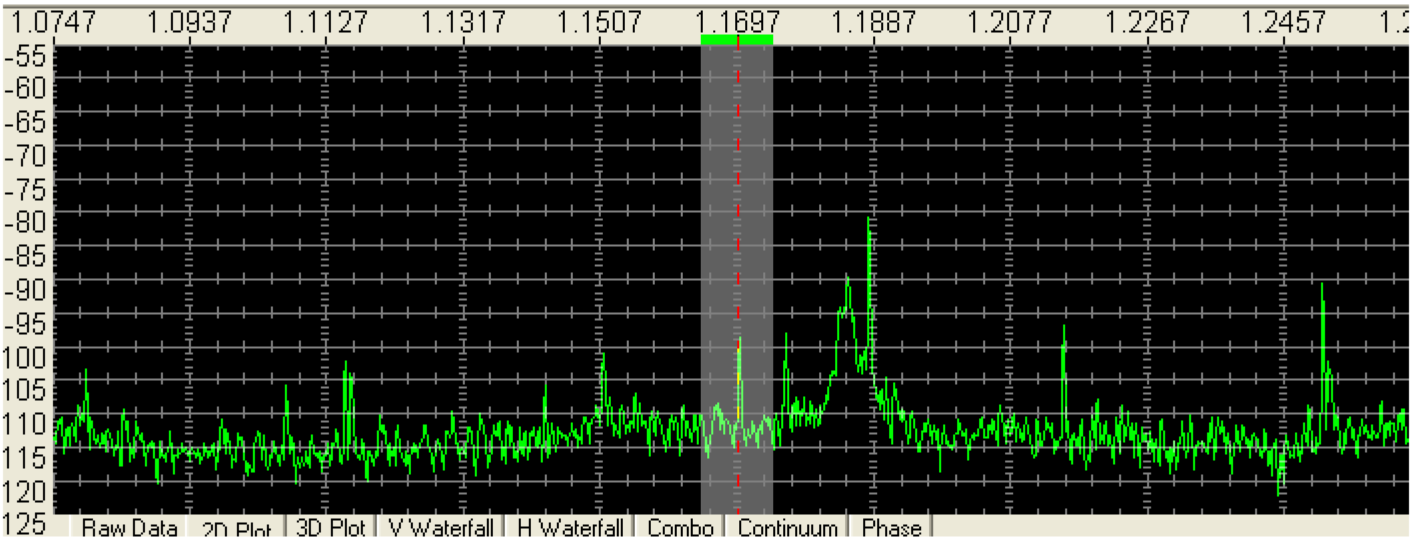
I don't have a test oscillator on 3.5 and 7 MHz, but I have been listening on the bands and the array showed a F/B of over 4/5 S-units on most DX stations. Of course these kind of signals is not stable enough to take a meaningful picture.

Conversely on MW we have very stable AM carriers from BC stations and from the two following graphs it can be shown a F/B of 36 dB !

Radio Koper (Slovenia) = 1.170 KHz - abt 90 Km. distance: <u>Front direction = - 62 dBm</u>

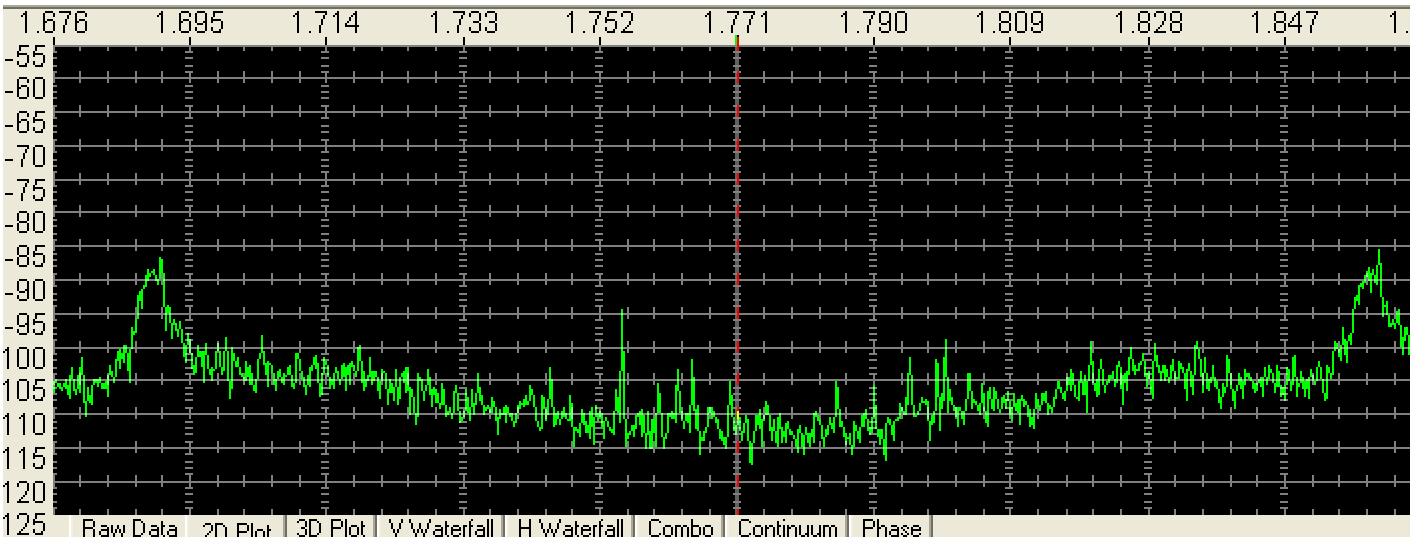


Radio Koper = 1.170 KHz -abt 90 Km. distance: <u>Back direction = - 98 dBm</u> è **FB ratio = 36 dB**



Really an outstanding Front to Back here, but on these graphs we start to see also which is my local noise problem; it is on about 1.185 KHz with a strength of – 100 dBm on SE direction and – 90 dBm on NW direction.

The peaks of this noise repeat every 170 KHz from MW to 3 MHz, slightly moving up and down, and they are strongest around 2 MHz. In the next graphics printout are shown the two peaks on 1.690 and 1.860 KHz with the 160 m. band noise in between at about - 105 dBm..



Unfortunately this is the same noise level I had on the previous 4-square array with the top loading wires. I thought they were responsible for the noise, but it was not so.

I make all the tests again and the substitution of the top loading wires with an Hi-Z amplifier on single element brought the noise level at exactly the same level.

At the moment my best receiving antenna happens to be the rotatable Flag, which is 10 meters high, well above the power and telephone lines, but I am sure the 4-square will come useful during the next DX season.

The K7TJR 4-square did not the miracle I was hoping but, on the other side, I am glad and very satisfied that my own array was well designed and correctly built !

The main plus of the K7TJR 4-square against my homebuilt one, calculated for a single frequency (1.825), where a F/B of 30 dB was achieved, are the following:

- It works very well, as shown before, not only on 160 m., but from MW to 80 and 40 meters. (I work only on Topband, but it's useful to give a look also on other bands when waiting for a DXpedition!)
- The Hi-Z amplifiers and the controller are built with good quality material which will last outside many years;
- Much simple controller with only two relays. The control cable required is a simple 3-wire, not a 16 wire cable like in my complicated homebuilt array (14 relays for 2 modes - 8 directions);
- The four feeding lines from the central box must have the same length to reach the antennas, but don't need to be a quarterwave at the operating frequency;
- No need to use the top-loading wires and their supports, but shorter simple antenna elements;
- No radial system required, just a ground stake for each vertical;
- Ready for use with easy installation and nothing to tune or adjust;
- Very honest amateur price.

Of course the performance should be better IF installed as advised by Lee, with full side dimensions and in a wide free space, but we are not living in a perfect world !

September 21, 2010 Luis IV3PRK