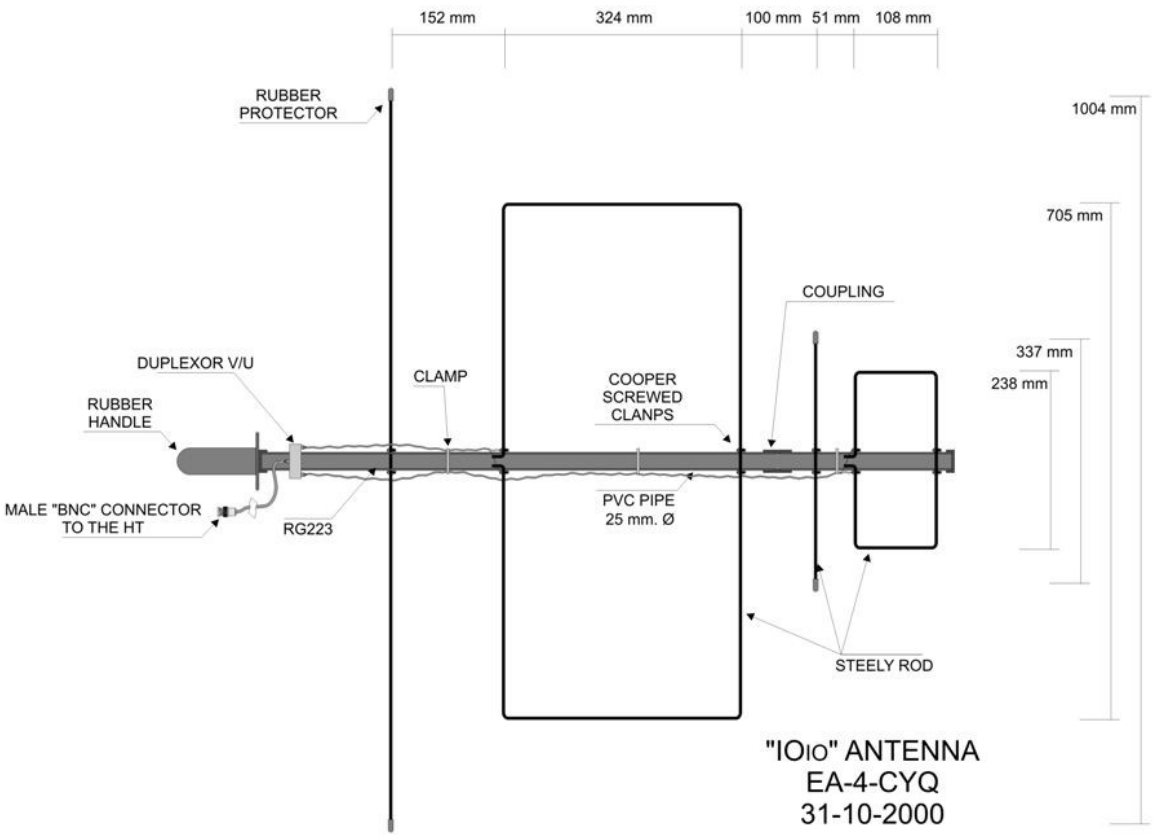
# THE "IOio" ANTENNA
## AND THE SATELLITES




*Scheme nº1: Scheme of the IOio antenna*

FM ham satellites can efficiently be worked in two ways, one of them sitting in our armchair with a complex fix station at home and the other with our HT in one hand and a hand held antenna in the other. All of them require skill and knowledge. With this article I will try to do the task of working under portable conditions easier.

All of us have read about working LEO FM satellites with an HT and a whip antenna, and if it is possible a high gain one (Photo nº1). To be honest, it is possible but you need skill to pick the modulations up the noise, aiming the antenna, changing the frequency and avoiding going mad. So any help will be welcome.

Some years ago the hams imagination who work satellites gave the outcome the Arrow antenna. This is a hand held antenna with just a boom and two yaguis set 90º each other (Photo nº2). One of them a three elements VHF yagui and the other a seven elements UHF yagui. Both of them are connected to a tiny duplexer. The whole are two linear polarized antennas with gain enough to work LEO FM satellites with an HT comfortably. This antenna ready to work is 1.5 meters length and three-dimensional, I

published and article in the Unión de Radioaficionados Españoles monthly magazine in January 2.005 about how to build it, of course the original is more lightweight, but I adapted it to be built with normal stuff and at the end it has the same performance.

But the original Arrow and what I built have an advantage with side effects. The advantage is that if you take all things apart to be transported it needs little room, so we can put it away in a suitcase to travel by plane or to be sent by mail. But this advantage turns out to be a drawback when we need to set it up because it takes the same time that a LEO FM satellite pass, over 10 minutes. It makes us lazy to work satellites with this antenna.

Taking all these things into account I became to think about how I could build an antenna which fulfil the following requirements:

1.- It must be lightweight enough to be hand held.

2.- It must have enough gain to work LEO FM satellites comfortably.

3.- It must be two-dimensional and the assembly process would be fast. So I could put it away in little room into the trunk and we could fast set it up.

I am sure with these premises you can build several models, but I made myself a question, What kind of antenna could be built with the same gain of a yagui and less boom length?. Well, the answer is the cubical quad antennas. All of us have read that when a yagui does not have many elements the cubical quads have more gain with the same boom length. But a cubical quad antenna is three-dimensional, so we do not fulfil one of the premises, because the squares could not easily be folded, this way seemed to be very complex mechanically.

*Photo nº1:*
*EA4CYQ working satellites with an HT and a high gain whip antenna.*

*Photo nº2:*
*EA4CYQ working satellites with a mobile transceiver and a home-made Arrow antenna.*

Then I remembered a kind of antennas designed by Jerry K5OE. He started on the basis of the Eggbeater from M2, which is no-directional with horizontal polarization towards the horizon and right circular polarized towards the sky, it is achieved by means of two phased squares. Jerry modified the square shapes to make a right circular

polarized directional antenna. The outcome was impressive and a lot of hams work with it satellites in a successful way, Jerry named it TPMII. You can read about my experience with this antennas at http\\www.eb4dka.tk., and of course at K5OE web.

Taking advantage of the experience I have achieved with the K5OE designs, and taking into account that it is not necessary circular polarization to work with a hand held antenna, because we can turn the antenna with our wrist to find the best polarity. The TPMII antenna could be reduced to a plane, so I have turned the antenna into a two-dimensional one. At this point I have fulfilled the three requirements I have proposed. Now I must polish the idea.

But at this point some doubts came over me, How will work a square electrically?, Will it need adapting the impedances?. To find the answers I had to dust the Antenna Book off and started to study again the chapters about squares and how to adapt them to 50 Ohm. The theory tell us that a square has an impedance about 100 Ohm, it is a SWR over 1:2.0. The antenna book offers as solution taking into consideration the adaptation impedances properties of a 1/4λ feed line, so if we feed this antenna with a piece of 75 Ohm feed line of 1/4λ electrical length (physical 1/4λ length by the feed line velocity factor), we have turned the antenna into 50 Ohm. This is the way the big HF squares are adapted to 50 Ohm.

But after reading this chapter I noticed that quad loop yaguis do not need this adaptation systems and they are usually fed directly with 50 Ohm feed line. I found the answer in the proper chapter, taking into account the distances of the reflector and directors we can get an impedance between 50 and 75 Ohm, so the adaptation system is not necessary. Then another question came over me, How will affect a linear reflector to the square in terms of impedance?. To get this answer I had two ways, to introduce all the details into the proper software to model how it works or to use an antenna analyzer.

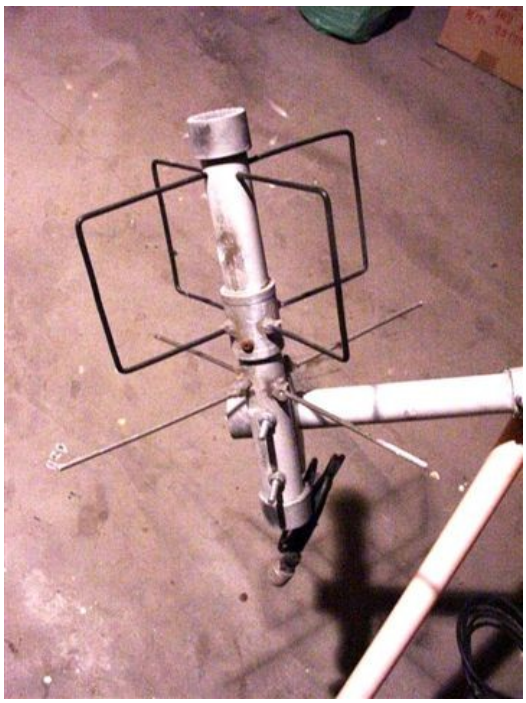


*Photo nº3:*
*TPMII designed by K5OE and home-made by EA4CYQ*

I think that the best is the real life, so I asked my friend Tomás EA4BUG for its antenna analyzer, a MFJ259-B. This device can analyze the impedance in the VHF band and it can only see the SWR in the UHF band, so I studied the VHF band and the impedance was between 40 and 75 Ohms into the satellite frequencies. It gives a SWR between 1:1.3 and 1:1.9. Later I analyzed the SWR into the UHF satellite frequencies and the outcome was the same.

The nowadays transceivers can work with this SWR without suffering any damage, on the other hand to build an adaptation system will complicate the whole and the antenna would be more complex to build, so I decided not to make life difficult.

*Photo nº4: Details of the elements fixed to the boom and feed line connected to the radiator.*

*Photo nº5: Detail of the duplexer*

You can see the IOio antenna measurements in the Scheme nº1. The boom is 25 mm external diameter PVC pipe, but you should use the type used in electrical installations because the PVC used in plumbing installations is thick and heavy. The elements are placed crossing the boom and to fix them I have set to each side a ½ screwed copper clamp which are used in electrical installations. These clamps will be the point in which we will solder the feed line ending (Photo nº4). The elements could be made of whatever rigid enough conductor wire to make the whole strong. It could be galvanized steel wire or aluminium rod. At the end of the rod, with which I have built the squares, I have blended the ending 90º before introducing into the PVC pipe so it will be stronger mechanically.

In the case you have the intention of using the antenna with a full-duplex transceiver, which is the most common way in FM LEO satellites, a duplexer will be necessary. I have installed one I had at home, the feed line length is not critical although it could slightly change the SWR but not significant, this is because the antenna in the resonant frequency is not exactly 50 Ohm as I have explained before. I do not advice use "PL" connectors if you have the opportunity to use "N" or "BNC", these lasts are more suitable for UHF frequencies and for the same reason you must use the best feed line you can purchase. In my case I used a piece of RG223 which is the same diameter than RG58 but with less losses.

If you are going to use the antenna only with an HT, you can purchase the tiny duplexer I know. It is made by Arrow Antennas and only supports 10 Watts, it has not connectors and the feed lines are directly soldered, it is set into the boom and it costs over 60 $.

And finally if you are going to use the antenna in public places, it is recommended to install rubber protectors at the end of the reflectors, so we will not cause damages to anybody.

*Photo nº6: My niece Úrsula aiming the IOio antenna*

*Photo nº7: Mi niece Sonia holding the folded IOio antenna*

After all the effort, I had to test the antenna, so analyzed the SWR of the whole with the duplexer set and it was similar to the before test. I must compare the IOio antenna with the Arrow antenna because it is our reference antenna. The first test was made aiming the antennas at known VHF and UHF terrestrial repeaters. Surprisingly, in VHF the IOio antenna got better outcome, but the Arrow was slightly better in UHF. After all, the performance was reasonable, because the Arrow has 3 elements in VHF and 7 elements in UHF while the IOio has the same elements in both bands.

The following Sunday I got up with the intention to carry out the "real" test, so we must test its performance working satellites. I printed a passes list of that morning and took the IOio and my THD7 HT and went to hunt birds. I was lucky because in two hours time I could test the three operative FM satellites. I made the following contacts:

- AO-27: PD5DJ, EA7FZS, EA7GO
- AO-51: DG9YIB, DJ1KM, EB4DEH
- SO-50: SP7THR, OO7EQ

All of us who work satellites know that the AO-51 is the most difficult to uplink so it was the best to test the VHF band performance, I reduced the power out down to 2.5 Watts and my uplink kept strong so I reduced again down to 50 mWatts and I could still listen to myself in the downlink, Amazing!. I did not have any problem to listen to any of the satellites from AOS to LOS, which confirmed the right performance in the reception. David EB4DEH who enjoy working whit a hand held antenna usually

records the passes to fill the log after and he sent me the recording by e-mail later, he was surprised by the performance of the antenna with 50 mWatts too.

Then David made a question, Which is the antenna name?, and I was amazed, I did not know how to explain how the antenna was and what is worse the antenna did not have name, I did not have time to react to that question and the satellite was going. After that I was looking at the antenna for a while and paying attention to its shape I thought it has the shape of the letters IOio, Why not? And the antenna was baptized.

*Photo nº8:*
*The IOio antenna ready to be put away*

*Photo nº9:*
*The IOio antenna hung under the trunk lid*

You can see my nieces as models taking the IOio antenna (Photo nº6 and Photo nº7). To say the true the uncle love for my nieces (what beautiful they are!) stands out more than the father love for the IOio (to gave bird to the antenna).

The boom has a coupling joint between the both antennas which lets separate in two parts to be put it away easily (Photo nº8). And finally how the idea was to put it away without taking up much room, you can see it hung under the trunk lid (Photo nº9).

I have tried to give all the details and tell my experience. One of my aims was that the antenna was easily to build, so I encourage you to build it and other ideas which are rounding your head. I am looking forward to listening to you through the satellites and reading your experiences at ea4cyq@amsat.org

You can find our experiences, video and audio recorders about ham satellites at EB4DKA WEB, where Pedro lets me leave these articles http://www.eb4dka.tk.

EA4CYQ
Juan Antonio Fernández Montaña

Note: This article was published in the Unión de Radioaficionados Españoles (URE) monthly magazine in February 2006 and AMSAT bimonthly magazine Nov./Dec. 2006.