THE ARROW ANTENNA
AND THE SATELLITES

I am going to try to give all the details to build this simple antenna, with which you will work LEO FM satellites "better" than a fix station, and all the things on the cheap.

Last year I published three articles in the Unión de Radioaficionados Españoles (URE) monthly magazine, with the intention to increase the interest about amateur satellites. In January I tried to convince you that with a simple satellite station with smaller antennas than a HF station and with a power out of 50 Watts in VHF and UHF, you could contact with the same countries than a HF station, so you could enjoy this hobby in a different way. In February I did my best to make you feel comfortable understanding the dish antennas, we studied and even we dared to build two different 2.4GHz feed dish systems that you could use successfully with the AO-40 or even with the terrestrial wireless systems. And finally in April I tried to explain how a linear transponder works, because this is the way the satellites can repeat the signals that they receive, I even proposed a terrestrial system.

With all the things we have learnt I do not have the intention of going more deeply into this world, on the contrary I am going to make you work to build a simple VHF/UHF antenna with which you will be able to work satellites with a dual-band 5 Watts HT, "better" than a fix station with the same power out.

THE SATELLITE POLARITY CHANGE

The majority of the satellites have a stabilization system which try to fix the "Z" axis, aiming it at the earth, or at least they try it. This seems to be achieved taking advantage of the magnetic field of the earth. But to fix the rotation around this axis is nearly impossible because of the absence of friction, so the stabilization system try to minimize the number of revolutions per minute.

I am going to concentrate on the LEO FM satellites. This spacecrafts are FM repeaters, but there are some differences between the terrestrial ones and these, the satellites usually receive in one band (generally VHF) and transmit in another different (generally UHF). As energy source they usually use solar panels and as aerial system they usually use two different types that I will explain later.

If we are in the VHF and UHF bands frame, the linear and circular polarizations are the most frequently used. I have not told vertical or horizontal, I have told linear on purpose. In relation to the circular polarization we can find the Right Circular Polarization (RCP), and the Left Circular Polarization (LCP). The most wide spread is the RCP which is used, for instance, in the 137MHz weather NOOA satellites.

The most common linear antenna used is an omnidireccional whip antenna, because directional antennas will drastically reduce the sole of the satellite. In relation to the circular polarization, it usually uses four phased ¼λ to produce this kind of polarization.

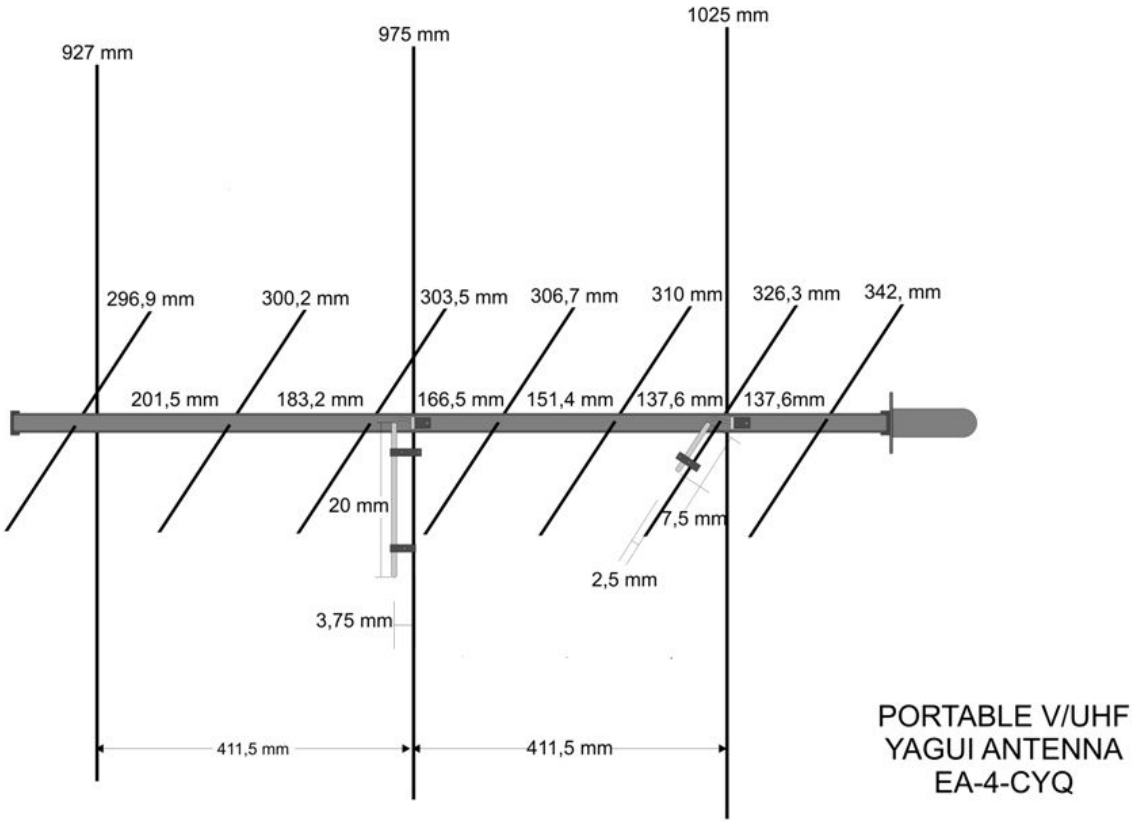

Figure nº1: Scheme of a dual-band portable antenna

A satellite is constantly turning around its "Z" axis, so if it has linear polarization, it will be changing in relation to us. So taking as a reference the surface of the earth, on some occasions we will receive horizontal polarization and on the others vertical or oblique, and it will take all the possible linear polarizations all through the time. Then you could think that the solution is the circular polarization, but it is not totally true as I will explain later, it only reduces the fading produced by the changes of polarization.

Until now all the things seem to be reasonable, but we must add other variable, when the waves go through the atmosphere electromagnetic fields, the polarization changes in a random pattern. So if a satellite has linear polarization, it would have vertical polarization in relation to us in an instant, but the atmosphere could change it into horizontal polarization, and we will receive it in the last one. In the same way if the satellite transmits with a kind of circular polarization, it will be reshape, and we will receive and imperfect circular polarization which is named elliptical polarization.

You will be thinking that this world is very complex, it is true, but hams are very stubborn and when they have the intention of working satellites in a serious way, they

install antennas with a switch system to change the polarization between horizontal and vertical or between RCP and LCP. So with our butterfly net, I am sorry it was a slip of the tongue, I would just like to say our waves net, we will reduce the fading produced by the changes of polarization.

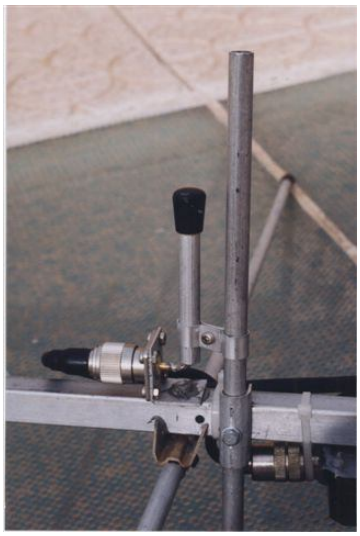

Photo nº2:
UHF Gamma-Match

Photo nº1:
Detail of elements assembled

Photo nº3:
VHF Gamma-Match

It is thought that if a satellite transmits with right circular polarization and we receive with a right circular polarization antenna, we will not have fading receiving the signal, it is completely untrue. But the fading will be less strong that if we receive with linear polarization. All of us who can experiment with the change of circular polarization know that the FO-29 satellite transmits with RCP, and on some occasions we receive it better with LCP, and we need to change the polarization several times in each pass to reduce the fading.

If we have all the things clear, we will understand that the better performance antenna will be that which can change its polarization to agree it with the polarization we can receive of the satellite. But a fix station does not have a set the antennas which can turn around its axis, it would be a very complex mechanism. So it is widely assumed that if we can change between two types of polarizations (vertical/horizontal or RCP/LCP) we will reduce the fading a lot.

We can come to the conclusion that if we have a handle antenna which we can aim at the satellite and we can turn it around its axis with our wrist, we will receive the waves of the sat with the best efficiency.

THE ARROW ANTENNA

Then, we are searching for a linear polarized dual-band antenna lightweight enough to be handled easily with our hand to aim it at the satellites. Hams enjoy building different designs and if you browse the net you will find a lot of interesting schemes.

One of the most wide spread designs is the ARROW antenna. This antenna is commercialized by Arrow Antennas, and you can purchase it in the market. It is very difficult to buy it in some countries, so if you want one you must only order it by the Internet at http://www.arrowantennas.com, I think it costs over 130$ plus shipping. Now if you dare to try to build one, you need neither to be crafty nor to be good with your hands.

In the Figure nº1 you can see the scheme I have built. It is not the original version, I have adapted it to be build easily, and of course, this model is heavier so I had to extend the boom to be supported as if it was a fishing rod (hi, hi, to "fish" waves of the satellites).

You can see in the scheme a three parts boom in which are placed two yaguis. The VHF yagui has three elements, a reflector, a radiator and a director. The UHF yagui has seven elements, a reflector, a radiator and five directors. The VHF elements are set in a plane and the UHF elements in another plane, between the planes are 90º. Both antennas have the same feed system, a "Gamma-Match", and it is necessary to install a VHF/UHF duplexer to connect the two yaguis to an HT.

But when we see the scheme it usually seems to be easy, but where can we find the stuff?. In my case I have found a couple of old TV antennas in a skip, I have taken advantage of the whole hardware, the boom, brackets, supports, ending pieces, etc.

As I have told, the boom is in three parts to make the transport and storage easy. The duplexer is fixed in one of the three booms in which are the radiators of booth yaguis. The UHF elements are fixed to the boom, on the other hand the VHF elements are detachable by means of wing nuts. In the photo nº1 you can see a director of each band fixed to the boom detail.

The photo nº2 shows the UHF gamma-match detail.

The photo nº3 shows the VHF gamma-match detail. It is very important to pay attention to how I have made the VHF gamma-match detachable by means of a screwed copper clamp soldered to a "N" female chassis connector.

In the photo nº4 you can see the whole set, I have even connected the HT and other accessories that I will comment later.

The photo nº5 shows all the pieces taken apart. The whole set is less than 1 meter length and 0.35 meters wide ready to be transported.

All the elements are of aluminium tube. The UHF elements are 10 mm. external diameter and the VHF elements are 12 mm. Both gamma-match are built with 10 mm. of external diameter aluminium tube. The condenser inner side is made of a piece of RG8 or RG213 feed line which I have removed the plastic cover and the wire-net.

All the connectors are "N" type except for the connexion to the HT in which I have used a BNC connector and a BNC/SMA adaptor.

The boom is finished with a rubber top in one ending and a handle in the other, to make it more manoeuvrable. In the endings of the VHF elements I have set a rubber

protector to avoid damaging to anyone while we are moving it. You must fell safe about the RF problems, because the power out will be less than 5 Watts in the higher frequency.

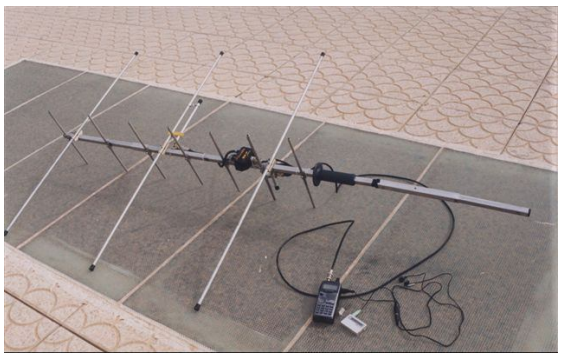

Photo nº4:
The whole set ready to work

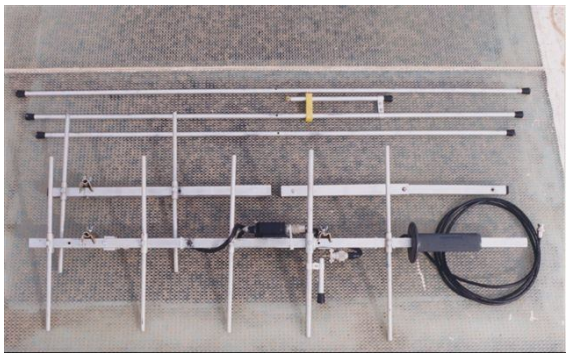

Photo nº5:
All the pieces taken apart ready to be transported

ADJUSTMENT

To adjust the two antennas, because although they are in the same boom they are two different antennas, we will need a VHF and UHF transmitter, and a SWR meter capable of both bands. If our SWR meter has low power scales we will be able to use our 5 Watts HT.

We will set the 145.900 MHz frequency in our HT, and we will connect the SWR meter between it and the VHF yagui. To bring down the SWR we can play with two points, one of then the gamma-match aluminium tube, moving it up and down, and the other changing the position of the bracket which fix the tube of the gamma-match to the radiator. When we get the minimum SWR we will fix the screws and nuts of the bracket. The yellow plastic piece you can see in the photo nº3 is used to make the whole stronger mechanically, in my case is a piece of gas pipe that I have found in the street (we are always picking things up from the ground).

To adjust the UHF gamma-match we will use the same method. We must set the 436.500 MHz frequency. The UHF gamma-match is not detachable and it does not need the yellow plastic piece because it is strong enough mechanically. You can see it in the photo nº2.

Once we have finished the individual adjustment we need to connect the duplexer. On some occasions we need to change the type of connector that the duplexer brings from the factory, it is always better than to install an adaptor. In my case I had to solder a “N” connector in the VHF branch of the duplexor instead of the original “PL” connector.

I do not advice to use “PL” connectors if you have the opportunity to use “N” connectors, because the last are stronger and more watertight, and of course it has lower losses.

To connect the duplexer to the HT I have used a piece of low losses feedline, in my case a piece of RG223. Now we must check again the SWR in both bands, but now we must set the SWR meter between the HT and the complete finished antenna. If all the things go well you will not have a noticeable difference between the before SWR and now, but on some occasions you must try to adjust it again following the same method described before.

We must pay attention to build this antenna taking into consideration that we are trying to receive very week signals transmitted with less than 1 Watt from more than 800 Km. We must respect all the measurements and use the best connectors and feedline that we can, to reduce the losses to the minimum.

THE FIRST REAL TEST

We can carry out the first test with terrestrial signals, aiming the antenna at a known repeater of VHF or UHF bands, and you will be impressed of the marvellous device you have built. This is an excellent antenna to work under portable conditions. But…, we have higher ambitions, at least looking at the sky.

When I listen to a couple of hams speaking about antennas, and one of them tells the other "My antenna is working very fine", I always make the same question, Which have you compared this antenna with?, and they usually answer that with anyone, it just works fine. This kind of answer usually gets on my nervous.

Then to carry out the real test I needed a friend to compare this antenna with a known antenna system. Of course my friend Pedro EB4DKA was the perfect candidate, he is an expert at working satellites under portable conditions, apart from he is my teacher in the satellite subject. He connected the antenna to his 5 Watts TH-D7 HT while I would stay at home with my usually fix antenna system, 15+15 elements crossed yagui in UHF and 6+6 elements crossed yagui in VHF, both of them have the possibility to change between LCP and RCP, I would transmit with 10 Watts of power out, because it is the minimum I can. We chose a clear 30º elevation pass of the AO-27 satellite over the Atlantic ocean to test it comfortably taking advantage of there would be not many people.

My fix station had double elements and double power out, although I have 30 meters of feed line. What would be the outcome?.

I could not believe my eyes, when Pedro got the right polarization and direction, his carrier left my carrier reduced to a negligible noise. His voice sound clearly over my modulation. In the worst case he always received the signals with the same level than my fix station. I am sure that you will understand now why I have spent so much time explaining the importance of the polarization and low losses above.

Photo nº7:
What holidays fishing satellites!

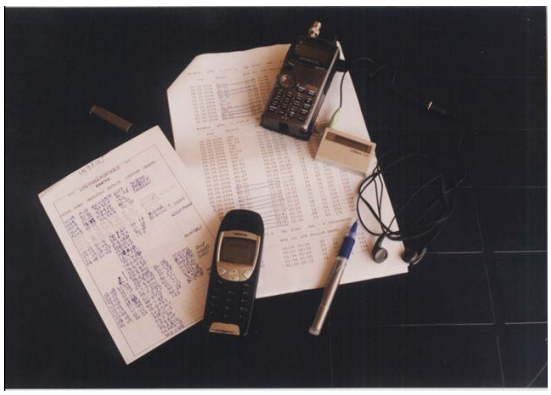

Photo nº6:
Accessories to work under portable conditions

THE HOLIDAYS TEST

But I was in doubt, would it be the luck of the beginner?. Well, I had planned my summer holidays with the family in the East of Spain because I can not enjoy the beach in my usual QTH, so we needed to have a change.

Others carry the fishing rods, flippers and the surfboard. I took my new antenna and a TH-D7 with two batteries (5 Watts and 2.5 Watts). I got a list of passes with the new locator and made a log in a piece of paper. I soldered all the necessary connectors to record the audio from the TH-D7 to a small MP3 recorder, so I will fill the log after the pass listening to all the dates, report signals, locators, etc. You can see all the items in the photo nº6.

You can see me in the photo nº7, I was lucky because the apartments had an enormous terrace with a beautiful view. In the photo nº8 the antenna is resting after the hard work while I was swimming. As usual, Murphy came to see me in the first attempt, and the battery of 5Watts was flat, without possibility of recovering. I thought of myself, poor thing! Could I make some contacts with 2.5 Watts?.

Well, I spent twelve days in IM97in and I could fill my log with the following contacts:

* AO-27: (5 passes), EA4DS/M, OE3KEU, HA8AR, IZ1DBY, ES1RF, PA5RWE.

* SO-50: (7 passes), 9H1FF, ON7EQ, PH7AT, DB3DH, F0CED, PA5RWE, DG9YIB, CT1DIN, DL9FAI/M, ON5NY, EB3GND.

* ISS: (1 pass, U/V voice mode), 9H1FF.

* ISS: (2 passes, V/V APRS mode), PD2RLD, IZ6FZS, OE5RPP, EB8AUU, IK2WSJ.

* AO-51: (2 pasess, V/U voice mode), CT1DIN, PA5RWE, ES1RF, DG9YIB, ON7EQ, DF3OJ.

Photo nº8:
Arrow antenna resting

Perhaps the most enjoyable moment was a SO-50 pass in which my friend Josep EB3GND and I were alone, and the satellite let us enjoy 10 minutes of a quite conversation.

Is it so difficult to work satellites?, Is it so expensive to work satellites?, perhaps you have found the answer in this experience.

I hope and it is my wish not only make the satellites closer but also have managed to transmit what I feel for this hobby. If I can help you or I can learn of you, please keep in touch ea4cyq@amsat.org.

Juan Antonio Fernández Montaña
EA4CYQ
73s

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