CHANGE YOUR HF AMPLIFIER AND YAGUI FOR AN AZIMUTH-ELEVATION ROTOR

If I can not explain it, somebody will write a lot against me!

I have the intention of demonstrating with this article that there is a branch of amateur radio which lets us make contacts with other hams around the world with less than 60 Watts and yaguis no longer than 3 metres length. I am sure you are thinking "This guy is going to tell me something about The Net". On this occasion you are making a mistake, this is the radio pure and simple.

I do not want that somebody misunderstand the headline, I think that the HF is the mother mode, but perhaps after reading this article, if you have problems with installing an HF yagui antenna and an amplifier of 1.500Watts, you take into account changing your mind and using less power and smaller antennas.

In conclusion, I will try to show the ham satellites world, I know you think that it is very expensive and difficult, but I will try to demonstrate that it is less expensive than an HF amplifier and antenna, and less difficult to install in your resident' association.

OUR AMATEUR SATELLITES

In the first place I will review the satellites types nowadays, after that we will see the different kinds of necessary antennas and rigs. I apologize for some things that I will say to hams who knows this amazing world because my intention is to open a window to those hams who do not know it. So I will try to simplify it in order to make some ideas clearer. I will give some references to set a "normal" base station to work satellites.

Roughly speaking, the amateur satellites could be classified by means of two different features, the orbit that they describe and the modes than they can work.

** Taking in mind its orbit:

1.- LEO satellites (Low Orbit Satellites). This kind of satellites are between 400 (jet-propelled as the ISS) and 2.000 Km from the earth. They usually describe polar orbits, so they always pass over the earth poles. Some of them describe an orbit which has an angle smaller than 90º over the Equator, so this angle defines the type of equatorial orbit. The orbit can be circular or elliptical but with small eccentricity. From the same place on the earth we can see them, at least, six times a day and with windows between 2 and 20 minutes. Its footprint lets communicate between Spain and the East coast of USA or the far East. Nowadays there are in operational mode the FO-29, SO-50, AO-07, SO-41, and the International Space Station (ISS), etc.

2.- Phase 3D satellites. These satellites have elliptical orbit with big eccentricity. They can be as close as 1000 Km in its apogee and as far as 64.000 Km in its perigee, (It is further than geostationary satellites which are over 36.000 Km). Its footprint is nearly as big as the half of the earth and we can make contacts with nearly the whole earth, taking in mind that this satellite appears in the east and disappear in the west. It has windows over several hours a day. Nowadays we only have a satellite of this type although we will have other in 2.007.

** Taking in mind its mode:

1.-Analogic satellites. These satellites work in voice mode. We can find two different types into this section. FM crossband repeater, they work like a terrestrial repeater, so we only have a channel to uplink in one band and other channel to downlink in other band. Lineal transponders, in this case the uplink is in LSB mode and the downlink is in USB mode. We have a wideband between 50 KHz and 250 KHz, depending on the satellite, so into this wideband several stations can carry out several QSOs simultaneously. We can work all the digital protocols supported by SSB mode, such as PSK31, CW, SSTV, etc.. Nowadays there are in operational mode AO-07, FO-29 and AO-40.

2.- Digital satellites, they work in FM mode to support protocols like AX.25. Some of them are BBS type, so they can store information uploaded by hams and other hams can download this information, there are even E-gates to exchange information with internet. This digital mode was in the limelight several years ago when The Net was not too spread, but nowadays is less useful. Other satellites work in a variant of AX.25 which lets us exchange keyboard to keyboard information live. APRS mode, other variant of AX.25, lets us exchange dates of a GPS or weather stations, it is beginning to be very useful. Nowadays are in operational mode NO-44, and ISS.

Amateur satellites are usually equipped with several modes, which can be configured from the earth. All of them have beacons to send telemetry to inform us about the state and status of their vital signs (temperature, voltage, energy, spin, etc.).

We still need another feature to define our satellites, the working frequency. Hams have been assigned several portions of the radio frequency spectrum to experiment on them. The same happens here, the satellites can work in 21 – 28 – 144 – 432 – 1.200 – 2.400 – 5.600 – 10.500 MHz. But we must not be scared, nearly all the LEO satellites work in 144 and 432 MHz, and only a minimal portion of them in the other frequencies, for instance the AO-40 has the uplink in 432 and 1.200 MHz and the downlink in 2.400 and 10.500 MHz.

Nowadays the tendency is to work in frequencies of 144 MHz and above. To work the 90% of the satellites I propose a station like mine, we will be able to TX and RX in 144 and 432 MHz and receive in 2.4 GHz. We can see it in the next photo.

Simple station to work satellites (EA4CYQ)

This is a multi-purpose setup which will let us work not only satellites but also terrestrial communications in FM and SSB mode in an excellent way, and we can test some interesting modes such as listening to EME, etc.

THE ANTENNAS

I know some hams which changed to satellites because their QTHs were surrounding by mountains and from there was very difficult to work terrestrial stations in VHF and UHF bands. I am trying to make clear that when the satellites are over near obstacles, between the satellite and our station there is nothing, only the atmosphere which attenuate a bit the signals. To get an idea, it is very difficult that a satellite transmit with a power out of more than 1 Watt and in the case of lineal transponders this power should be spread between several stations and the noise, so the power is over 0.1 Watt in much occasions. Even so, our station will be able to receive this weak signal.

With the aerial system that I propose you will do not have any problem to work this kind of satellites. You only have to take into account to install the best feed line that you can or install a preamplifier in the UHF band. In my particular case, in the UHF band I do not have any preamplifier, however I have 30 metres of ½" coaxial feed line. In VHF band I use 30 metres of RG213 without any preamplifier. Of course all things can be improved, but you can take this set-up as a reference.

The height is not very important!. I only have the end section of three meters of a 18 cm. tower and three guys rope. If we have an obstacle in one direction which does

not let us work the satellites bellow 5 degrees, for instance, Do not worry!, We will be able to work the rest of the orbit!.

Now we need to steer our antennas to aim them to the satellites. If we have an azimuth rotor, we have the half of the rotor system installed. If we do not have into account the cheapest of 60 Euros, which do not send reference to the remote control, the rest of them will be suitable, because we do not need to move big antennas, only a couple of yaguis of 3 metres length.

To raise our antennas, we can use whatever elevation rotor which sends information of its position to the remote control. But the elevation rotor is a bit difficult to find, there are not very much brands and models, the most known is the Kempro/Yaesu G-550. We can find some kinds of azimuth-elevation rotors in a whole, the most known is the Yaesu/Kempro G-5500 and G-5400.

But the satellites are always in movement so with the assistance of our PC we will know where we have to aim our antennas. This work can be made easily by means of an interface which automatically can steer our aerial system. I have installed an interface made by a local dealer EA4TX, you can find several inexpensive models in the market, perhaps the best known is the KCT. All these interfaces have an easy installation between the RS232 port and the rotor remote control, it will assist you without complaint.

To choose the antennas we must take into consideration that signals from the satellites are in constantly change of polarisation, so we must choose cross yaguis with circular polarisation and RF relays to change between Right Circular Polarisation (RCP) and Left Circular Polarisation (LCP). You can work with linear polarization but the fading will be strong and we will not listen to the satellite comfortably. As all of us know, the antenna is the best investment in our station.

VHF: The classic configuration is 8+8 elements with Circular Polarization (CP) and the possibility to change between RCP and LCP. I only have 5+5 with a boom of less than 3 metres. I chose it because the signals in this band do not have strong attenuation so we do not need much more gain antennas.

UHF: The typical configuration is, at least, 15+15 elements with CP and the possibility to change between RCP and LCP. The boom is only 3.4 metres long. It is necessary to install the best feed line you can or a preamplifier.

SHF: I have the typical and minimal configuration, a 60 cm. offset parabolic dish from an old TV satellite system. As a prime feed antenna we can build easily a Patch-Feed or an Helix between three and six turns. I have built and tested both of them, and the outcome was the same. I eventually decided to install the Helix as a prime feed antenna because it liked me more. I got the schemes from http://www.g6lvb/60cm.htm and http://www.homepages.ihug.co.nz/~jpsl/a_simple_patch_antenna_feed.htm.

You can see the typical set-up of this kind of antennas in the photos of my aerial system, and you can find much many on The Net.

Side view of a typical aerial system of a base station for amateur satellites

THE RIGS

All the things we have learnt will help us to choose the rigs. To work FM LEO satellites we will need a full-duplex biband FM rig with less than 50 Watts of power out. If we have the intention of working digital modes we have to add a TNC. The rig what fulfil the requirements is the TM-D700, although whatever mobile full-duplex biband will work fine. We always can choose two monoband rigs.

To work SSB LEO satellites we will need a full-duplex biband all mode rig with 50 watts or a couple of all mode monoband rigs. We can find several models in the market, TS-2000, FT-847, IC-910, TS-970, IC-821, TS-960, FT-826, FT-836. I have to warn that these rigs are a bit expensive, and perhaps if you just have a monoband all-mode rig you will only need another one to the other band. It was my case, I had an IC-706MKIIG and I purchased a TM-255E later. I had to assist the UHF band with a small power amplifier to get the necessary 50 Watts.

We just have a complete amateur satellite station to work LEO satellites. If we have the intention of working the AO-40 we will need to receive the 2.4GHz band. In this band the loss in the feed line is enormous, so we will have no option but to install a downconverter. We can choose the I.F. (Intermediate Frequency), the most usual are 29 MHz, 50 MHz or 144 MHz. This kind of device is easy to find in the market and it is not very expensive. The cheapest one is a commercial TV satellite LNB, the AIDC 3733 of Transystem which needs a light adaptation, K5GNA usually does it. There are other models designed for hams which do not need modifications such as SSB Electronic, Kuhne, etc. I purchased the Kuhne model for 240 Euros and I installed it into a waterproof box outside, it was attached by a N-N connector to the prime feed antenna. I supplied 12 Volts by 30 metres RG213 feed line, I had to build a bias-T

which gave the 140 mA needed. This downconverter have a gain over 30 dB, so we can use a feed line with high loss and 100 metres length, for example RG-58.

THE TIME HAVE ARRIVED

This is only a phrase, because we have being learning since we have started to read. But I am sure that when you are here you have just understood your tracking software, you have wired the rotors and interface, you have browsed The Net and have being reading for hours about this kind of satellites. I am sure that you know a near ham who are a bit boring with your questions but he listen to all your comments because you pay him some beers and coffees, well I was only pulling your leg. But all the jokes have something of thru.

We must be down-to-earth, a satellite base station needs much time to be installed, because at the beginning we start listening with a portable HT the FM satellites, and if we have a TH-F6 or TH-F7, we have even listened the SSB satellites. After that we will try listening the low passes with our colineal antenna. With a depth sense of shame we will try to uplink and when we listen our own shaking voice, it is a moment that we can not never forget. Nowadays I still feel uneasy when I listen to myself.

When it happens, you became hooked on this hobby. You will not stop until you see your base station working. But until I arrived here I have suffered and enjoyed a lot, you can read my experiences in an article that I have written “An amazing satellite experience, TPM II and Eggbeater II antennas”. I remember those years with affection because I was 4 years in that stage.

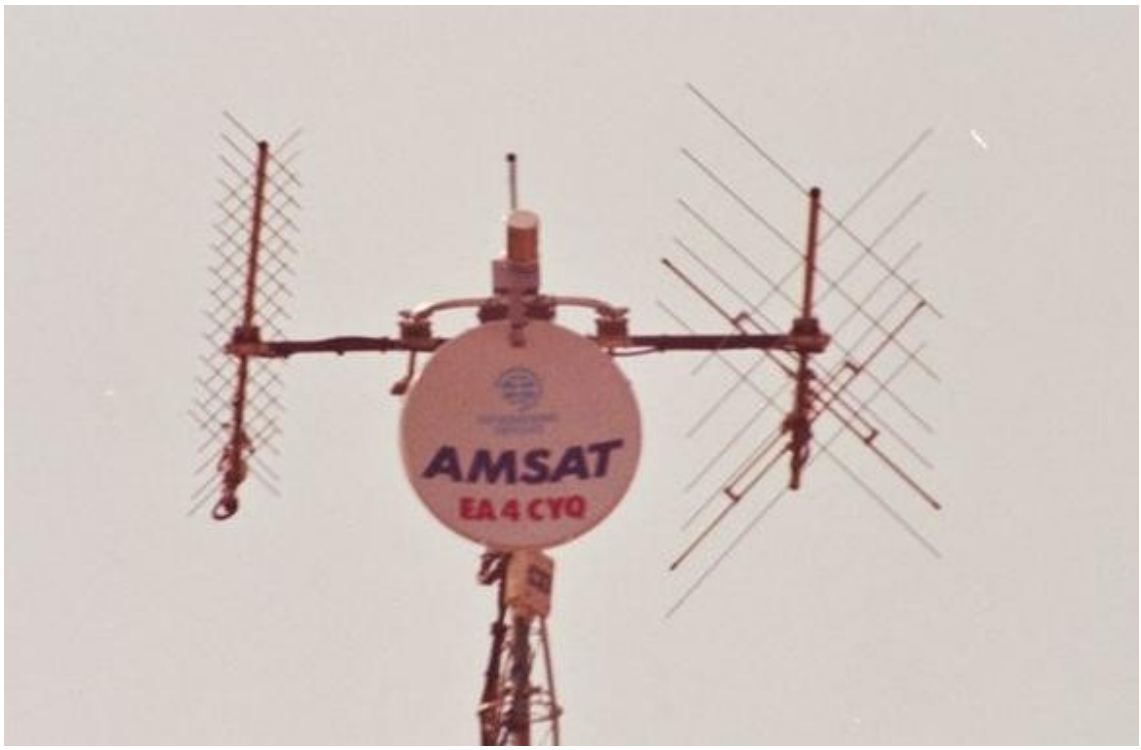
After that period I installed a rotor, two yaguis, a rotor interface and purchased a TM-255 because I had an IC-706MKIIG. I began to test all the modes and LEO satellites. I made hundreds of contacts with Europe, the East coast of USA, etc.. The best remembers are:

- I made a contact with KG4NLZ who was on holidays in the Niagara Falls with an HT and a whip antenna. We took advantage of the UO-14 satellite over the Atlantic Ocean. It was his first contact with an European ham, he could not believe his eyes.

- I have uploaded and downloaded messages in the mailbox of the ISS with hams of all the world, I can remember ZL2CIA, JH4DHX/3, XE2ARF, LU8YYN etc.

- While I was driving back from my summer holiday I spoke several minutes with EB4DKA who was with his HT and whip antenna as if a terrestrial repeater was.

- Of course, to speak with Valery Korzum RS0ISS while he belonged to ISS crew (Yes an astronaut!), was the most amazing one. That night I could not sleep.



Front view of a typical base amateur satellite antennas

NOW IS THE "AO-40" TIME

After being working LEO satellites with my yaguis antennas for more than 18 months, I decided to try the most difficult one, the AO-40. But it turned out to be the easiest.

At the beginning I described this satellite, it is very important to remark that its orbit is elliptical, so when it is in the apogee, it is over 64.000 Km from the earth. When a satellite is there, its movement in relation to us is negligible, Its movement is so slow than we only need to readjust the aim of our antennas one time per hour. This means that we do not need a rotor interface and a PC to follow this satellite. This is the only satellite that many people work with a tripod to steady the antennas, and only a time per hour they go out to the terrace to readjust the aim.

It is so easy to work this kind of satellites and it will give us so much happiness that many hams only work this kind of satellites, and they do not work LEO satellites.

We can uplink to the satellite in 432 or 1.200 MHz, but we will use 432 MHz to make the most of our LEO setup. The downlink is in 2.4 and 10.5 GHz, so we will listen to it in 2.4 GHz because the needed setup is cheaper. I chose a downconverter with I.F. in 144 MHz. So we will uplink in 432 MHz in LSB mode and will downlink in 144 MHz in USB mode (the downconverter I.F.). I never needed more than 60 Watts in the uplink to work this satellite.

I would like to make clear two things, one of them is that 60 Watts of power out is the higher power that I have needed in the worst case and the second thing is that to

use as I.F. receiver, it is not necessary the best one, because the downconverter gives enough gain, over 20/30 dB. For example, EB4DKA have used the TH-F7 with success.

Pedro EB4DKA and I have made many tests with different antennas, horns, 40 turns helix, offset parabolic dishes with several prime feed antennas and yaguis, Pedro has even uplink with a TPM II successfully. But after all, the best performance/size relation is a 0.6 metres offset parabolic dish.

At the time of writing this article I have been active in this satellite only three months. I have to work to earn a living although I have to recognise that I have got up between 3 and 5 AM more than a night to enjoy passes over the east to work Japan. I have made more than 240 different stations, I can remark:

- In voice mode I have worked all the continents from the West coast of USA, K6KLY to Australia VK3KOS, Christmas Island VK9XW, India VU2RM, South Africa ZR2DX, the Reunion Island FR5AT and the Antarctic 8J1RF.

- In digital modes I have worked with our well-known friend Emily W0EEC in PSK31 and RTTY from the West coast and SSTV with several Japanese stations JA1PSS, JH2ESW, etc.

I am radio amateur working in HF bands for more than 20 years and I have never made so many marvellous contacts with these strong signals, and you?

The majority of these satellites are designed by hams. AMSAT, Amateur Satellite is the association which defend our interests in coordination with the other associations of hams, universities, NASA, etc.. It is not necessary to belong to this association to work satellites, but if we join it we will have a lot of benefits, such as important news, a forum, keplerians, and we will support the best association we have.

I only had the intention of showing the tip of the iceberg, because I think this is the branch of our hobby with more future and in which we can learn more interesting things. I hope the curiosity I have woke up into you would be enough to change your mind about your trajectory into this hobby.

I would like to express my gratitude to all hams who devote its time to spread their knowledge and experiences, because all of us learn of them and we will not give a wrong step, saving time and money. You can keep in touch at ea4cyq@amsat.org.

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