DISH ANTENNAS

2.4GHz DISH FEED SYSTEMS
TO WORK THE AO-40 SATELLITE

Last month we could see in the Unión de Radioaficionados Españoles monthly magazine an item about ham satellites focused on the necessary antennas, equipment and accessories to work with these spacecrafts.

In HF, VHF and UHF the most usual antennas are verticals, dipoles and yaguis, but when we need to work higher frequencies dishes give us better performance. But this kind of antennas usually make hams feel a bit uneasy, because we think it is a complex antenna designed to other applications.

If two years ago somebody would have told me that I will work into the hams radiofrequency spectrum with a dish, I would be in stitches, because my opinion about this kind of antennas is the same I have comment in the above paragraph.

My intention whit this article is, in the first place, to understand how these antennas work, and later, to build some 2.4 GHz dish feed systems with which we will be able to listen to the AO-40 satellite. There are several types of 2.4 GHz antennas, but dishes are which have better performance.

Unfortunately there are a lot of wireless nets very close to the AO-40 satellite downlink, but in this case if you have the intention of making a point to point linkage you could take advantage of these dish feed systems to connect two points several kilometres away. I and the majority of us do not have a SWR meter for this frequency, but it will be not very important because this kind of devices usually work with extremely low power out.

THE PARABOLIC DISHES ANTENNAS

The dish antennas are a metal surface which works as a reflector, and the radiator is placed in the focal point. This surface can be built with different stuff:

- Solid aluminium or steel, the aluminium is wide used due to its lightweight.

- Perforated aluminium dishes or a structure with a aluminium mesh is used in big dishes.

- Fibreglass covered with a conductive coating in its concave surface. This method is used in big dishes to make it more lightweight.

- The barbecue grill describes itself.

Photo nº2:
Solid aluminium offset fed dish

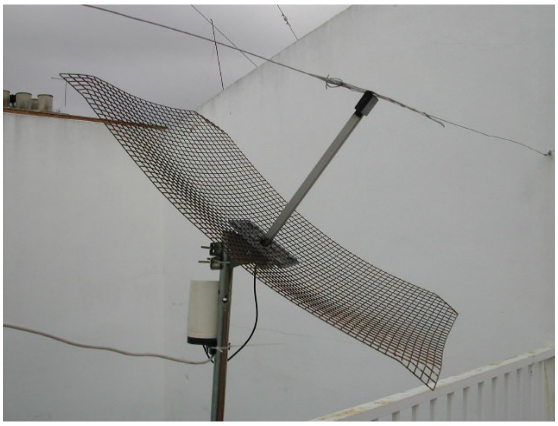
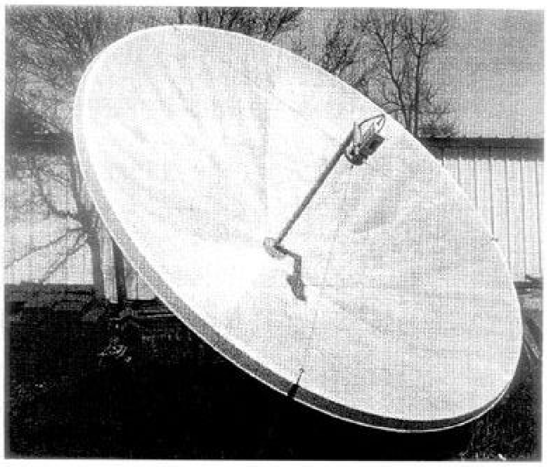


Photo nº3:
The barbecue grill

Photo nº1
Solid aluminium centre fed dish



We can find several types of dish antennas taking into consideration the equation which define its shape. We can make the following classification:

- The centre fed dish. The focal point is placed in the central axis of the dish. Its mathematical equation is the parabolic reflector. See photo nº1.

- The offset fed dish. The focal point is placed out of the central axis of the dish. Its mathematical equation is the spherical reflector. See photo nº2.

- The barbecue grill. The focal point is placed in the central axis, this is the least spread model. Its mathematical equation is the toroidal reflector. See photo nº3.

If we could test these three types of dishes with a similar size, the offset fed dish will be which offers the best performance, followed by the central fed dish and finally the barbecue grill. In the small centre fed dishes and barbecue grill, the size of the feed system itself reduces the performance, because it causes shadow, so the bigger the feed system is the worse the performance will be. The bigger the dish is the less noticeable the effect is. This effect does not affect to the offset fed dishes. The barbecue grill has worse performance because of its mathematical equation, however it has a wide angle of radiation, so it is easier to aim.

Although we can find all these types in the market, the most wide spread is the offset fed dish, so we will concentrate our effort on it, although we will see some interesting features of the other models.

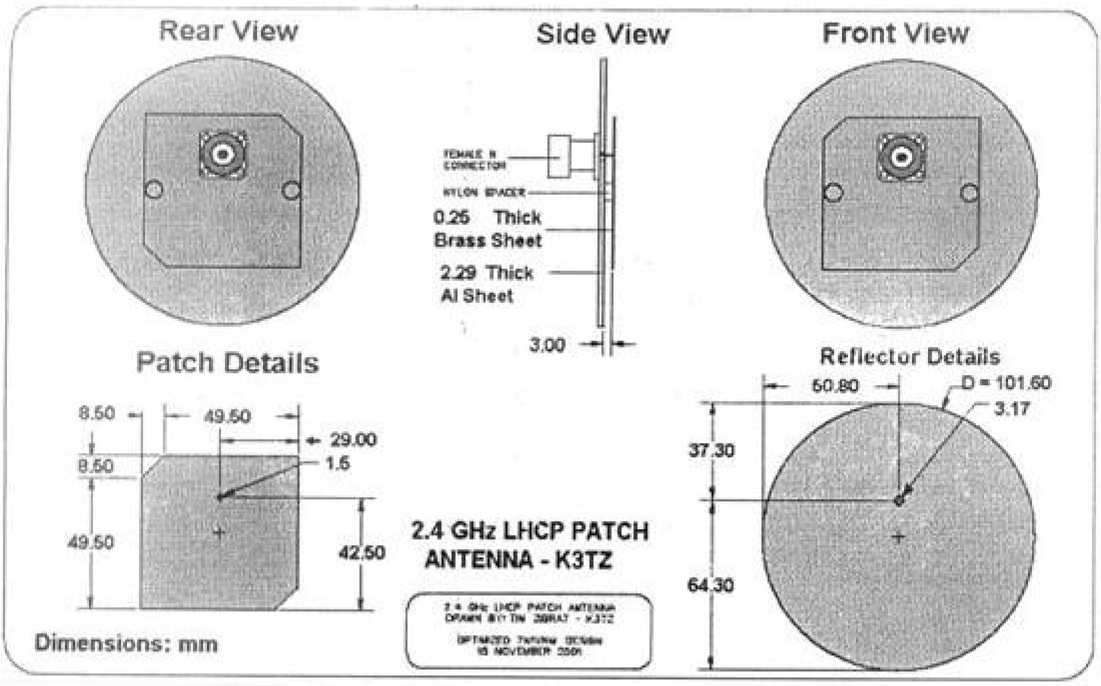


Figure nº1: Scheme of a patch-feed

Each dish antenna has a personal feature known as the focal ratio, we must work out it to know what kind of feed system will work better.

So we need to find out two distances:

- The diameter of the dish (D), we must consider the effective diameter, the edge will not work. If our dish has different horizontal and vertical diameters, we will choose the smaller, it is generally the horizontal.

- The depth of the dish (P), we must set the dish in horizontal position, facing toward the sky. We will place a rigid piece of metal or hardwood supported in the edges as if it was the diameter. We must measure the deeper point.

First of all we will work out the **focal distance** (Df), this is the distance between the surface of the dish and the feed system. The equation is:

$$Df = D^2 / (16 * P)$$

With this date we will work out the main feature of our dish the **focal ratio** (Rf). The equation is:

$$Rf = Df / D$$

The focal ratio is smaller than 0.4 in the centre fed dishes and it is between 0.4 and 0.7 in the offset fed dishes. But we must not be confident and we must work out our figure.

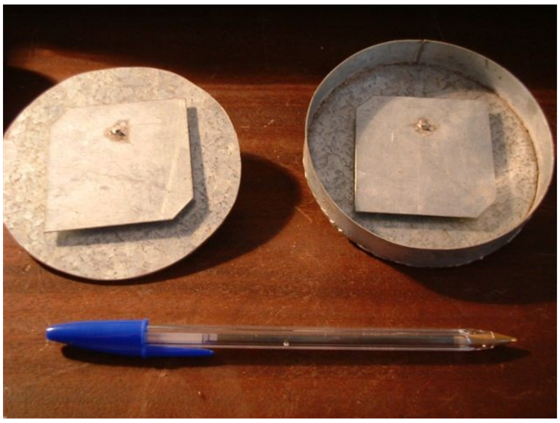


Photo nº4:
Front view of a normal and a ringed patch-feed

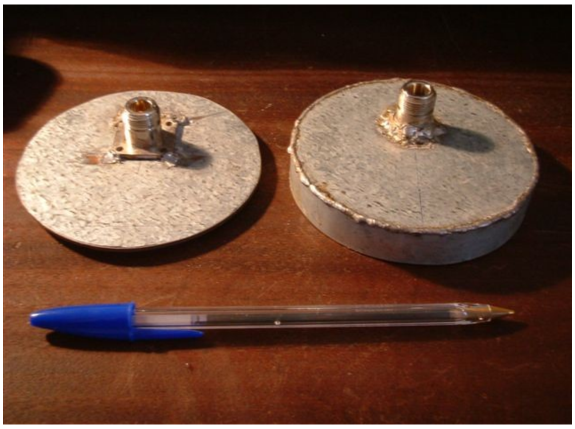


Photo nº5:
Rear view of a normal and a ringed patch-feed

Photo nº6:
A ringed patch-feed attached to a downconverted supplied by work in portable of

THE DISH FEED SYSTEMS

These feed systems must light the whole surface, they must flood the dish with RF, so it is very important that they are set exactly in the focal point.

If we do not take into consideration this feature we could make two kinds of mistakes:

- If the feed system over-light the dish the reception will be noisier, and it is very important in these frequencies.

- If we under-light the dish we will not make the most of the surface because a part of it will be underused.

Another important feature of the feed systems is the polarity, they can be linear or circular polarized. We must be careful with the circular polarization because it changes to the opposite when it is reflected in the surface. If our feed system is Left circular polarized, the whole antenna will work with Right circular polarization and vice versa.

Fitting to a real case, the AO-40 transmits with Right circular polarization, so we must build our dish feed system with Left circular polarization to reduce the fading to the minimum. Of course we could work with linear polarization but we will reduce the gain and increase the fading.

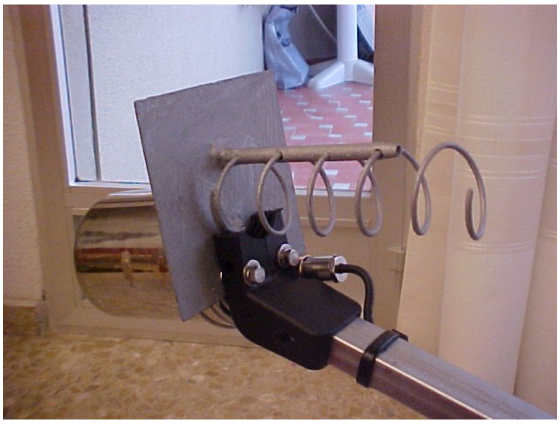


Photo 7:
Helix of 5.25 turns set

Photo 8:
Details of the connection between the Helix and the downconverter

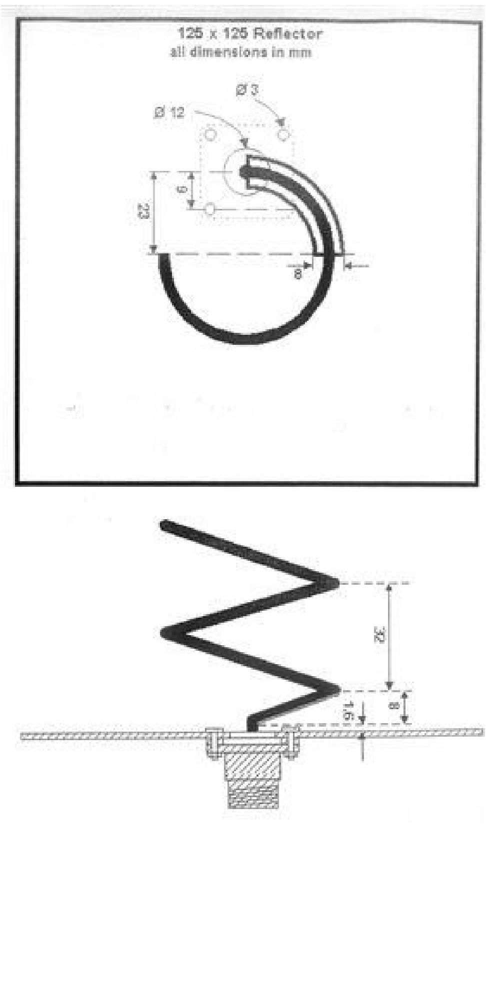


Figure nº2:
Details of the helix, reflector and the impedance adaptation system

After a lot of tests, hams have chosen two types of dish feed systems:

- <u>PATCH-FEED</u>

It is necessary two pieces of metal sheet with the proper measurements, one of them is the reflector and the other the radiator. According to the point in which we connect the radiator and the shape of it, we could get different polarizations. We are interested in Left circular polarizations, so we can see in the figure nº1 the K3TZ design, it is one of the most wide spread.

The scheme is friendly, I built it with two galvanized steel sheets of similar thickness. To build the radiator you can use cooper circuit board because it is extremely thin. To keep the separation between the two sheets you can use at least three small pieces of fibreglass or methacrylate.

This dish feed system has a wide angle of radiation, over 150º, so we can only use it with 0.3 focal ratio dishes. Therefore we can only use it with centre fed dishes.

If our focal ratio is a bit higher, we will need to reduce the angle of radiation. It can be achieved installing a ring between 18 and 25.4 mm, so we will get over 130º.

You can see the two prototypes in the photo nº4 and photo nº5. In the photo nº6 you can see the patch-feed working attached to the downconverter and supplied with batteries in the portable station of EB4DKA.

<u>HELIX</u>

This antenna has a worthy feature, it has a nearly perfect circular polarization. It clearly has two different parts as we can see in the photo nº7:

- The reflector. It can be square or circular and it is usually built with 2 mm thickness galvanized steel sheet to make it strong enough to support the whole. The minimal size is shown in the figure nº2.

- The radiator. It is built with 3 mm diameter solid cooper rod, you can find it in a electrical store. If you have a piece of ½" hard feedline of 50 Ohm, you can get it from the central wire. You can see the measurements in the figure nº2.

The Helix is 40 mm. of inner diameter. In the first ¼ turn, a piece of 8 mm. wide galvanized steel sheet is following the shape of the helix has been soldered. It is very important to adapt the impedance of the whole to 50 Ohm. To build it with Left circular polarization you must look at it from the "N" connector and it must turn counterclockwise.

The Helix lets us change the wide of the angle of radiation, according to the number of turns. In the same way that a yagui, the longer it is the narrower the angle of radiation will be. The experience has shown us the following rule to light the dish properly:

" I f a dish has a focal radio of 0.N, the helix must be built with "N" turns".

So the centre fed dishes usually need 3 turns helix, and the offset fed dishes up to six turns. In the photo nº8 we can see the helix attached to the downconverter 2.4GHz/144Mhz.

But we must take into consideration that the losses in 2.4 GHz are enormous, so the connection to the downconverter must be the best feed line of the minimal length, although the best is to do it with a rigid “N” to “N” connector as you can see in the photo nº8.

Now we must set the downconverter into a waterproof case, the manufacturer usually offers one which fit well, but I made one of a galvanized steel can and it seems to work fine.

If you try to buy a commercial helix fed dish of 2.4 GHz, it is usually into a waterproof case to avoid damages and humidity. In my case I do not decided to do it, however I covered it with a protective coating to avoid rusting and damages because of the solar radiations. To know if a waterproof case will affect to the helix performance, you must set it into a microwave with a glass filled with water during 1 minute. If the device keeps cold it is suitable.

My last piece of advice is to balance the finished whole, so the azimuth rotor will not suffer for life. I decided to build a structure of pipe used in electric systems with two arms, so the elevation rotor is placed in the centre, and to equilibrate in the other axis I needed a two kilos plumb counterweight, one kilo for each arm. You can see the whole structure in the photo nº9. The photo nº10 shows the dish with the feed system and the downconverter into the waterproof case ready to be taken it up to the rotor.

Photo nº9:
Detail of the structure to support the dish, you can see the counterweights

Photo nº10:
Antenna ready to be taken up to the rotor

I tested the Helix, the patch-feed and the ringed patch-feed. The patch-feed was noisier and the Helix and the ringed patch-feed had similar performance. I made up my mind to the Helix because it seems to be more beautiful. Do you think so?

I hope you will not be afraid of dishes any more. It is said that you will defeat your enemy if you know him better.

You can find further information in the following ARRL publications:

- The Radio Amateur's Satellite Handbook
- International Microwave Handbook
- The ARRL UHF/Microwave Experimenter's Manual
- The ARRL Antenna Book

And of course, there are a lot of Webs of hams. I will advice you visit http//www.ultimatecharguer.com of our friend Robert W0LMD, and http//.www.g6lvb.com of G6LVB.

I wish to express my gratitude to my parents for their understanding, to my friends and hams for the time they waste with my tests and to my wife to let me steel her time.

Juan Antonio Fernández Montaña
ea4cyq@amsat.org
EA4CYQ

Note: This article was published in the Unión de Radioaficionados Españoles (URE) monthly magazine in February 2004.