



Antennas Construction

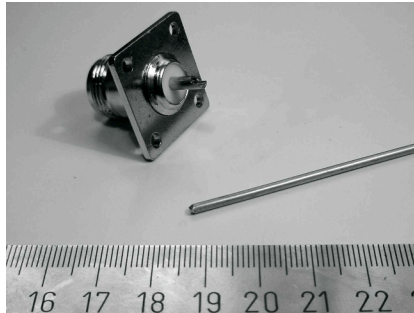
Quarter wave omnidirectional antenna for 2.4 GHz

This is a simple and cheap omnidirectional antenna good for surveying signal strength using wlan tools. It is built using an N-type female chassis mount connector and five short lengths of copper or brass wire. The driven element is the wire soldered into the central conductor of the connector, with a length of one quarter wavelength. The four radials are also one quarter wavelength long, and are soldered into each corner hole of the connector. Each groundplane is cut to length and then bent over at 30 degrees from the horizontal to attempt to match the impedance to 50 Ohms. The gain of this antenna will be between 3 dBi and 4 dBi depending on final tuning.



**Parts list:**

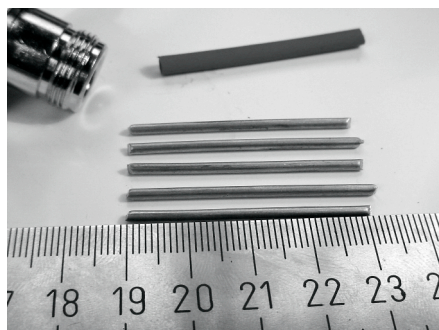
- one N-type chassis mount female connector with four-holes flange (good quality one with teflon insulator is recommended)
- 20 cm of copper or brass wire of 2 mm of diameter

**Tools required:**

- ruler and goniometer
- pliers
- a file for metal
- a small rat-tail file for metal
- one powerful soldering iron of about 80 -100 W
- one soldering iron
- solder
- vice
- hammer

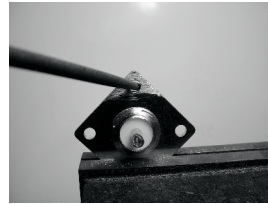
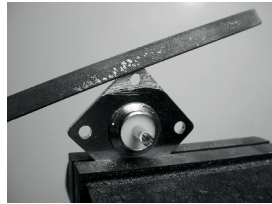
Construction:

- 1) With the pliers, cut the wire in 5 pieces of 4 cm each.

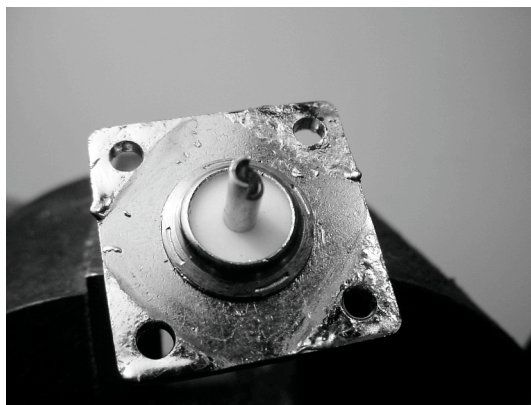




2) File the flange of the connector near the holes in order to remove the plated surface. Use the rat-tail file to do the same on the internal part of the holes. This is done to prepare the surface of the connector for tinning.

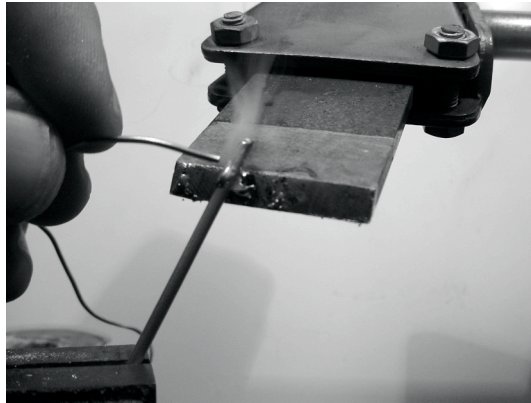


3) Power on the high power soldering iron and let it heat for a couple of minutes. Apply the soldering iron to the connector until it gets hot (really hot! Be very careful!), but avoid melting the dielectric. Then tin the area around and inside the holes by applying solder until it flows. Avoid filling the holes with solder. Tinning is required to facilitate the process of soldering the wires to the connector.





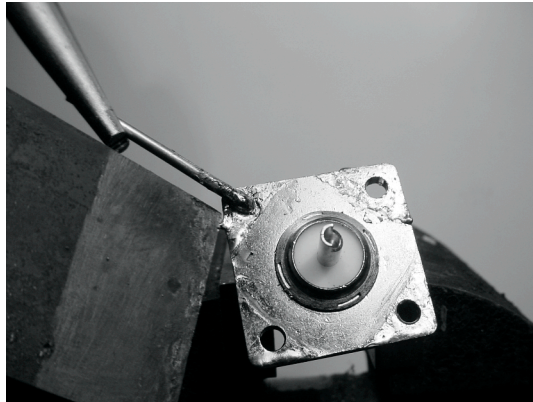
4) Smooth with the file one side of each of the wires. Tin the wires for around 1 cm at the smoothed end, using the high power soldering iron.



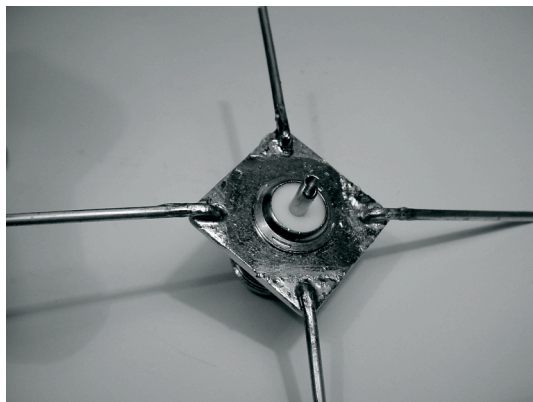
5) Bend at 90 degrees 0.5 cm of the tinned side of the wires with the pliers. Do it for four of the wires, leaving one straight. Help yourself with the vice and the hammer.



6) Place firmly the connector in the vice, avoiding damaging the screw. Place the tinned bend side of one wire in a hole of the flange. Keeping it with the pliers, position the wire horizontally and along the direction of the diagonal. Apply the high power soldering iron shortly to the connector and with a small amount of solder, solder the wire to the connector. Avoid melting the dielectric of the connector. You may find useful getting somebody else keeping the wires in place with the pliers while you are soldering.



Repeat the same procedure for the four wires.



7) With the low power soldering iron, tin the central pin of the connector. Keeping the straight wire vertical with the pliers, solder its tinned side in the hole of the central pin.

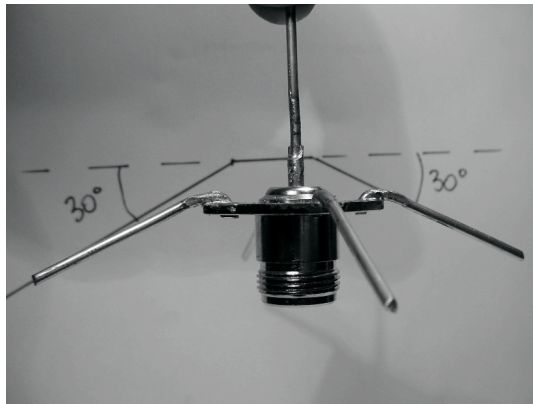




8) Trim the exceeding part of the wires under the flange.



9) With the pliers, bent over the four radials at 30 degrees from the horizontal plane. This is done to match the impedance to 50 Ohms. To facilitate this operation, you may draw the 30 degrees angle on paper, and compare the antenna with it as shown.

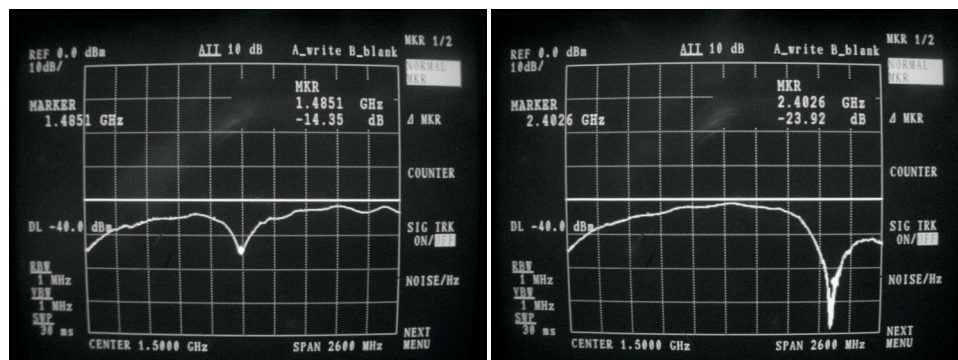




10) Trim the radial at a length of 3,05 cm measured from the corner of the flange. Smooth the end of the wires with the file.



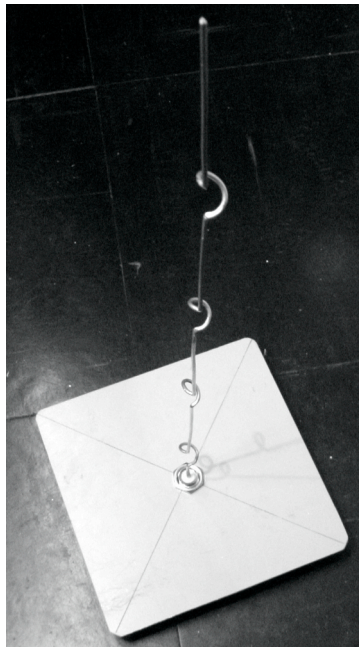
11) Trim the central wire at 3.05 cm measured from the flange surface. If you have a Spectrum Analyzer with Tracking Generator and a Directional Coupler, you can leave the central wire 0.5 cm longer and check the curve of the reflected power of the antenna. Trimming the wire at steps of 0.1 cm or less, you can tune the antenna to have the minimum reflected power at a frequency of 2.44 GHz. The pictures below show the display of the Spectrum Analyzer at the beginning and at the end of the tuning procedure. A difference of a few millimeters changes the frequency of resonance of the antenna of some hundred MHz. You are done!





Omnidirectional collinear antenna for 2.4 GHz

This antenna is very simple to build, requiring just a piece of wire, an N socket and a square metallic plate. It can be used for indoor or outdoor Point-to-MultiPoint short distance coverage. The plate has a hole drilled in the middle to accommodate an N type chassis socket that is screwed into place. The wire is soldered to the center pin of the N socket and has coils to separate the active phased elements. Two versions of the antenna are possible: one with two phased elements and two coils and another with four phased elements and four coils. For the short antenna the gain will be around 5dBi, while the long one with four elements will have 7 to 9 dBi of gain. We are going to describe how to build the long antenna only.



**Parts list:**

- one screw-on N-type female connector
- 50 cm of copper or brass wire of 2 mm of diameter
- 10x10 cm or greater square metallic plate

**Tools required:**

- ruler
- pliers
- file
- one soldering iron
- drill with a set of bits for metal (with a 1.5 cm diameter bit)
- a piece of pipe or a drill bit with a diameter of 1 cm
- solder
- vice or clamp
- hammer
- spanner or monkey wrench

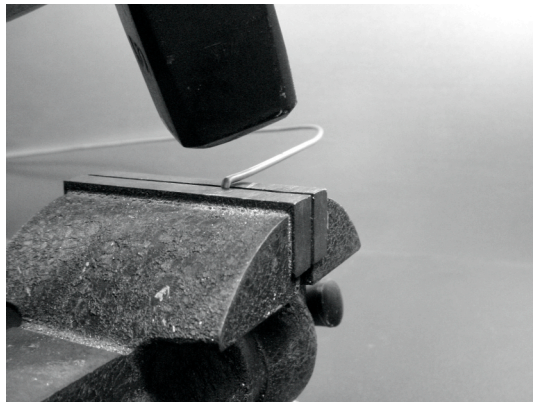


Construction:

- 1) Straighten the wire using the vice.

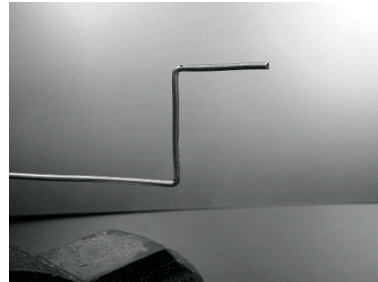
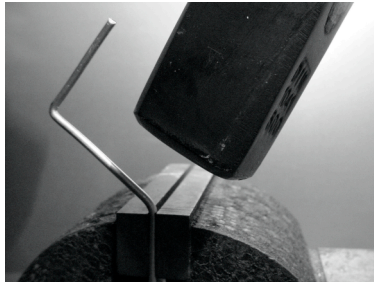


- 2) With a marker, draw a line at 2.5 cm starting from one end of the wire. On this line, bend the wire at 90 degrees with the help of the vice and of the hammer.





3) Draw another line at a distance of 3.6 cm from the bend. Using the vice and the hammer, bend once again the wire over this second line at 90 degrees, in the opposite direction to the first bend but in the same plane. The wire should look like a 'Z'.



4) We will now twist the 'Z' portion of the wire to make a coil with a diameter of 1 cm. To do this, we will use the pipe or the drill bit and curve the wire around it, with the help of the vice and of the pliers.

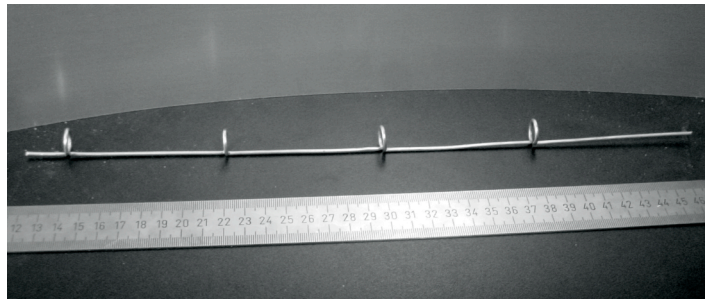


The coil will look like this:

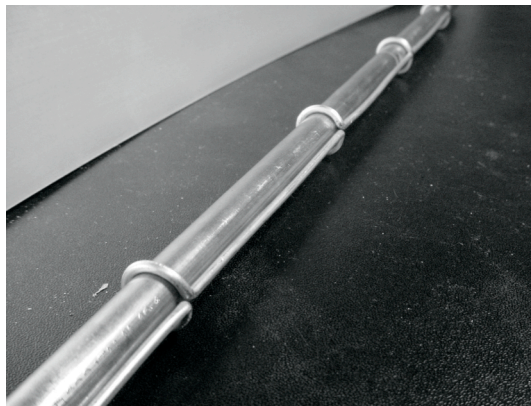




5) You should make a second coil at a distance of 7.8 cm from the first one. Both coils should have the same turning direction and should be placed on the same side of the wire. Make a third and a fourth coil following the same procedure, at the same distance of 7.8 cm one from each other. Trim the last phased element at a distance of 8.0 cm from the fourth coil.

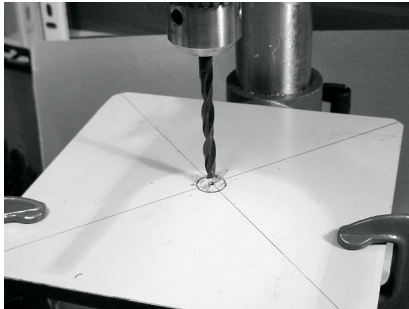


If the coils have been made correctly, it should now be possible to insert a pipe through all the coils as shown.





6) With a marker and a ruler, draw the diagonals on the metallic plate, finding its center. With a small diameter drill bit, make a hole at the center of the plate. Increase the diameter of the hole using bits with an increasing diameter.



The hole should fit exactly the N connector. Use the file if needed.



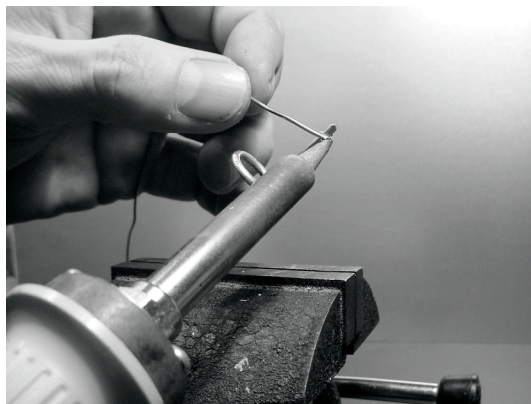
7) To have an antenna impedance of 50 Ohms, it is important that the visible surface of the internal insulator of the connector (the white area around the central pin) is at the same level as the surface of the plate. For this reason, cut 0.5 cm of copper pipe with an external diameter of 2 cm, and place it between the connector and the plate.



8) Screw the nut to the connector to fix it firmly on the plate using the spanner.

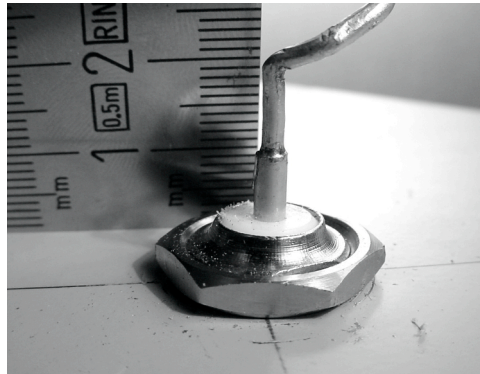


9) Smooth with the file the side of the wire which is 2.5 cm long, from the first coil. Tin the wire for around 0.5 cm at the smoothed end helping yourself with the vice.





10) With the soldering iron, tin the central pin of the connector. Keeping the wire vertical with the pliers, solder its tinned side in the hole of the central pin. The first coil should be at 2.0 cm from the plate.

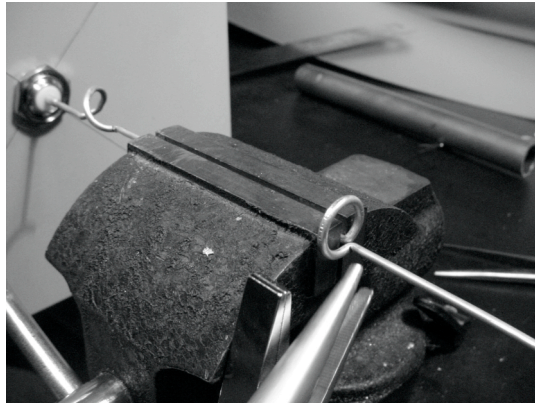


11) We are now going to stretch the coils extending the total vertical length of the wire. Using the use the vice and the pliers, you should pull the cable so that the final length of the coil is of 2.0 cm.

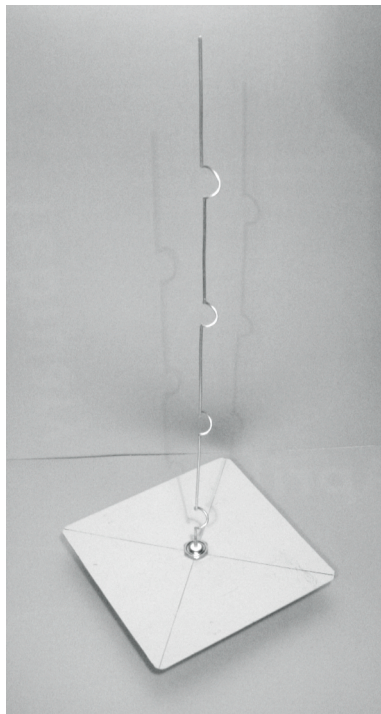




12) Repeat the same procedure for the other three coils, stretching their length to 2.0 cm

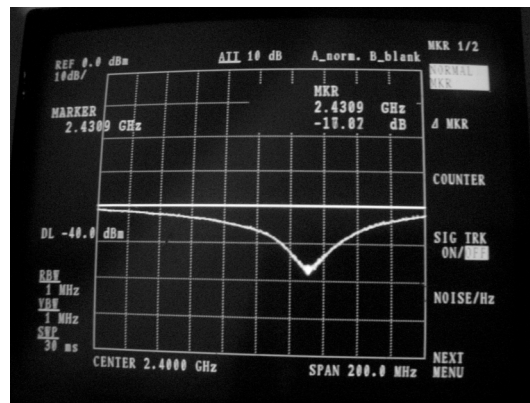


13) At the end the antenna should measure 41.5 cm from the plate to the top.





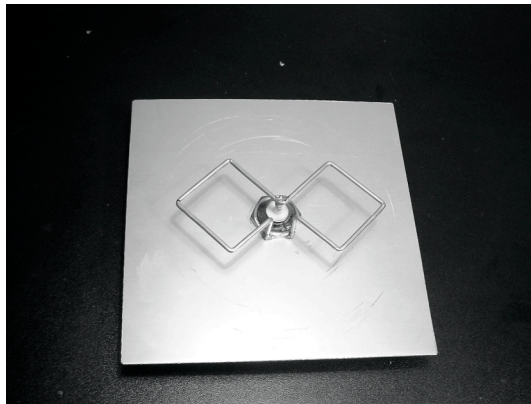
14) If you have a Spectrum Analyzer with Tracking Generator and a Directional Coupler, you can check the curve of the reflected power of the antenna. The picture below shows the display of the Spectrum Analyzer.





Biquad antenna for 2.4 GHz for stand-alone use

This antenna is a directive one, useful for a short distance Point-to-Point link. It may be also used as a feeder for a Parabolic Dish or Grid. It is very cheap and quite easy to build, requiring just a piece of wire, an N socket and a metallic plate. The plate has a hole drilled in the middle to accommodate an N type socket. The wire is shaped as an '8', but with squared angles and then soldered to the N socket. For this antenna the gain will be in the order of 10 to 12 dBi, with a beamwidth of around 60 degrees.



Parts list:

- one screw-on N-type female connector
- 30 cm of copper or brass wire of 2 mm of diameter
- a square metallic plate of at least 12.3x12.3 cm (aluminum is preferable)

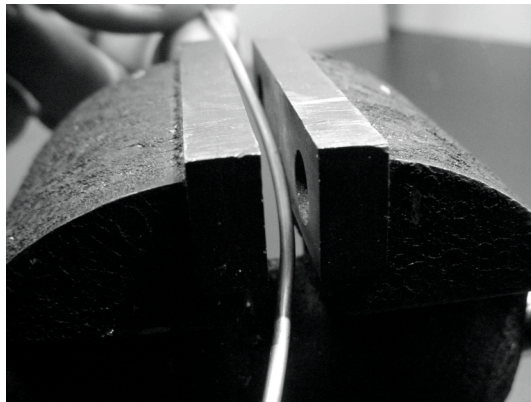


**Tools required:**

- ruler
- pliers
- file for metal
- small rat-tail file
- cutter
- saw for metal
- soldering iron
- solder
- drill with a set of bits for metal (with a 1.5 cm diameter bit)
- vice or clamp
- hammer
- spanner or monkey wrench

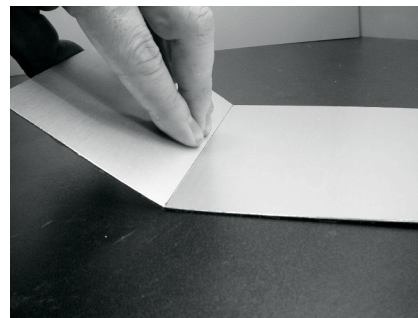
Construction:

- 1) Straighten the wire using the vice.





2) Cut the metallic plate to have a square shape of 12.3x12.3 cm. To do this, you may use the saw, but we suggest to use a thin (0.8 to 1.5 mm) aluminum plate, which can be cut with a cutter. Draw the correct dimensions on both sides of the plate with a marker. Carve the drawn lines with the cutter pressing firmly, helping yourself with the ruler. Do this a couple of times, on both sides of the plate. Bend the plate over the lines until it breaks.

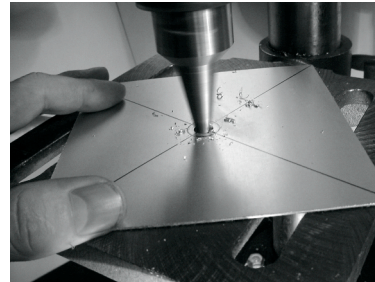
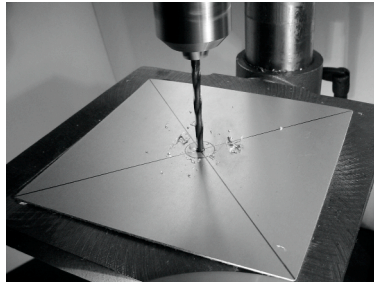


3) The edges can be now very sharp. Be careful when handling the plate. Use the file to smooth the edges all around.





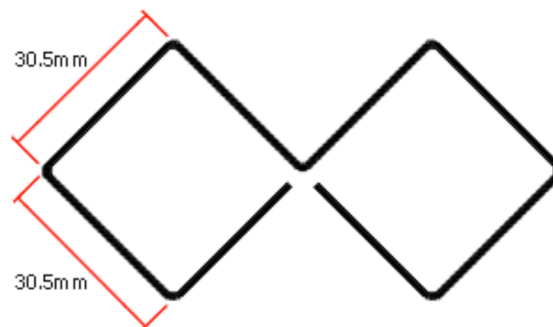
4) With a marker and a ruler, draw the diagonals on the metallic plate, finding its center. With a small diameter drill bit, make a hole at the center of the plate. Increase the diameter of the hole using bits with an increasing diameter.



The hole should fit exactly the N connector. Use the file if needed.

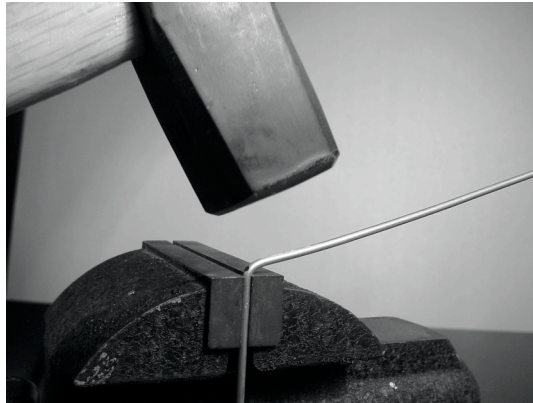


5) Now we want to shape the wire as an '8', composed by two squares connected on one edge. The two squares have a side of 3.05 cm.

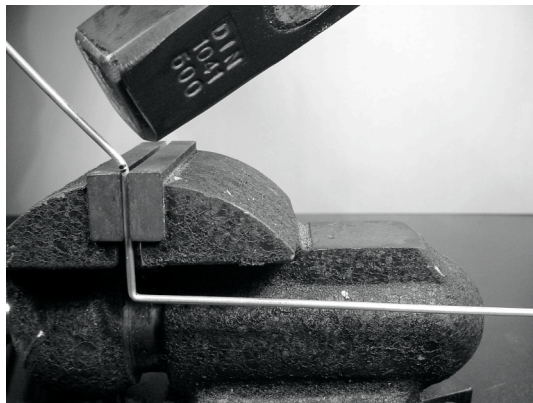




Bend the wire at 90 degrees in his central point using the vice and the hammer.



6) With a marker, draw a line at 3.05 cm from the edge, and bend the wire at 90 degrees in this point with the vice and the hammer as before, but in the opposite direction (it should look like a 'Z').





7) Draw another line at 3.05 cm from this new edge, and bend the wire at 90 degrees in this point, in the same direction as before.

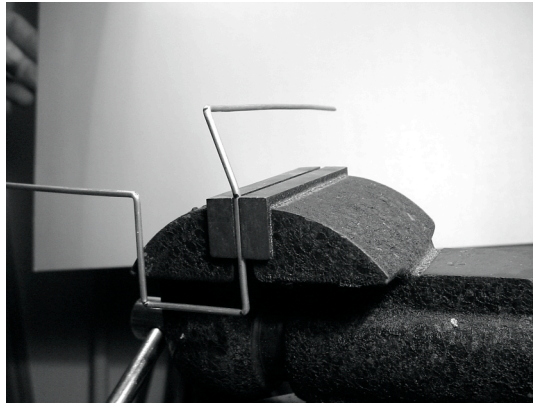


8) Draw now a line at 3.05 cm from the last edge, and a second line after 2.3 cm from the first one. Bend the wire at 90 degrees in the second line, in a direction orthogonal to the plane containing the wire, as shown.

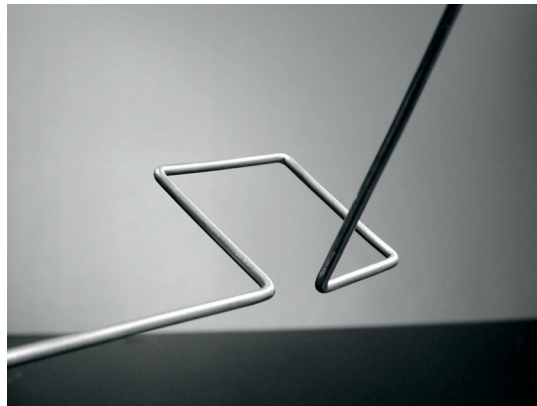




9) Bend the wire at 90 degrees in the first line drawn in the previous step in order to “close” the square, as shown.

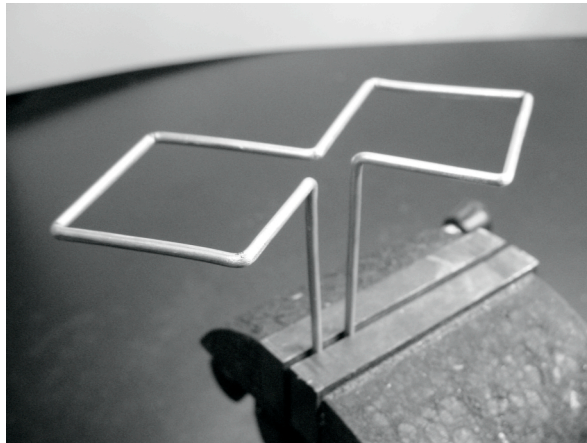


The wire at this point should now look like this:





10) Shape the second half of the wire to obtain another square, repeating the procedure described in steps from 6 to 9. The result should be this one:



11) With the saw and the rat-tail file make two small, half-round shaped cuts in the connector's nut at 60 degrees one from each other. The cuts should be on two contiguous edges of the nut, and should be large enough to fit half of the wire's diameter. File also around the cuts.

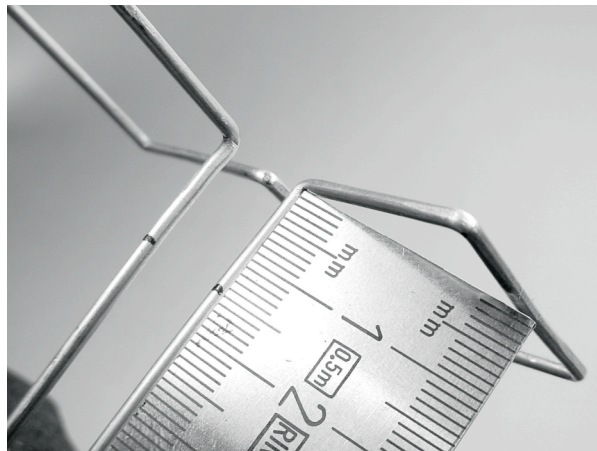




Be careful not to cut too deeply inside the nut: enough metal should remain to ensure its robustness.

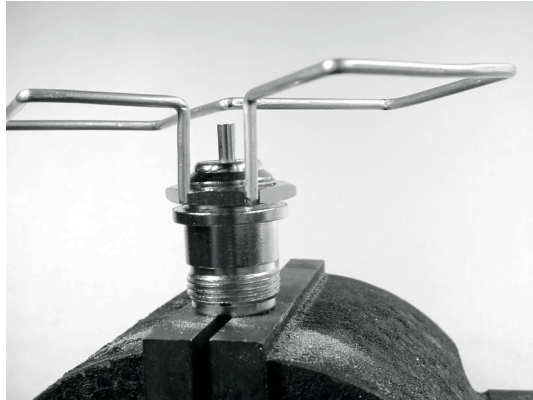


12) Trim the two ends of the wire at a length of 1.5 cm.

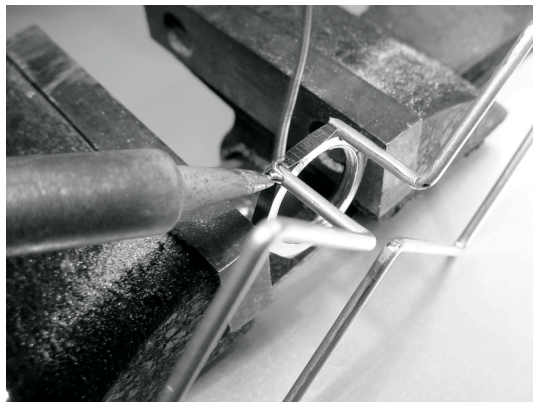




13) The wires should now fit in the nut's cuts as shown.

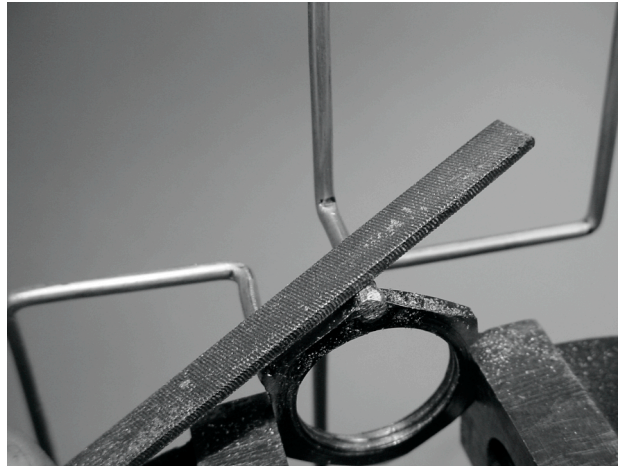


14) Tin the ends of the wire for 0.5 cm. Tin around and inside the cuts of the nut with a small amount of solder, and then solder the wires to the nut.





15) Remove the exceeding solder with the file, so that the nut can be screwed correctly.

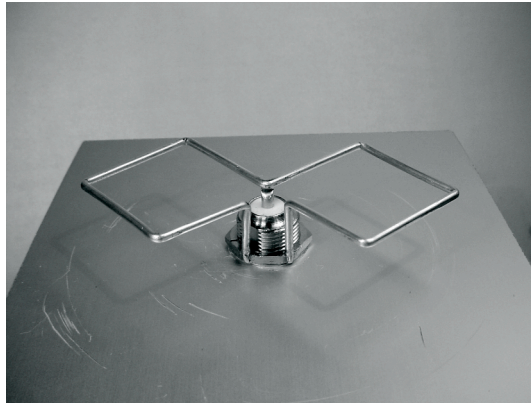


16) Insert the connector into the hole of the metallic plate and screw the nut with the wire soldered on it.





Rotate the nut so that the diagonals of the two wire squares are parallel to the side of the metallic plate. Then screw it firmly with the spanner.



17) We now want to solder the central pin of the connector to the center of the shaped wire. You may have either a short or long type of N connector, as shown.



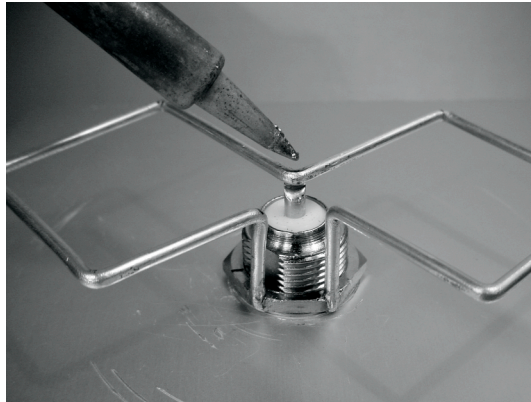
The central pin of the long type may be soldered directly on the shaped wire, while the short type of connector needs an additional short piece of straight wire to be soldered into the central pin.



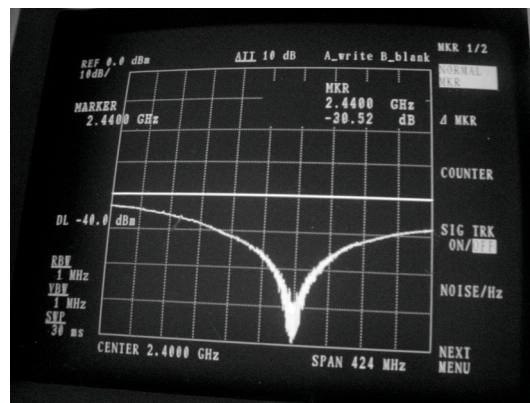


We are going to use the long type of N connector.

18) Tin the central pin of the connector and solder the center of the shaped wire to it.



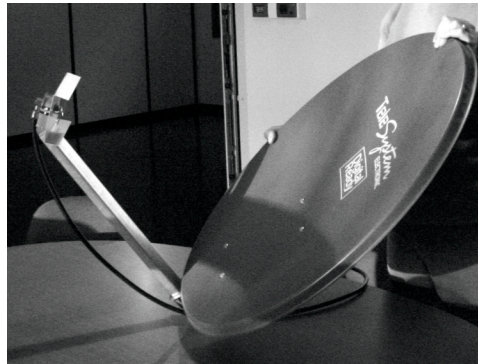
19) The antenna is now completed. If you have a Spectrum Analyzer with Tracking Generator and a Directional Coupler, you can check the curve of the reflected power of the antenna. The picture below shows the display of the Spectrum Analyzer.



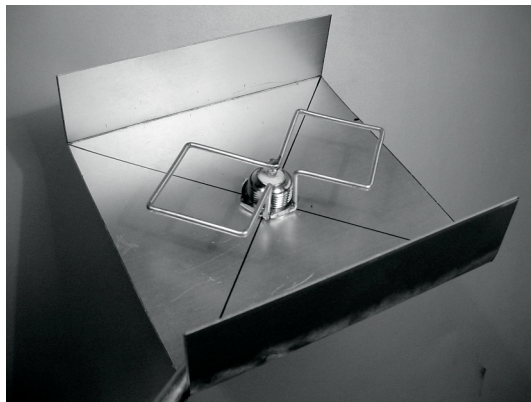


Biquad antenna as a 2.4 GHz feeder for a Parabolic Dish

This antenna is essentially the same as the stand-alone Biquad, but with a modified reflector plate allowing it to be used as a feeder for small Parabolic Dishes. You can use one of the very cheap dishes that are used to receive Satellite TV. These dishes may have a centered feeder (called LNB for Satellite TV) or an off-set one. This Biquad feeder can be used in both cases with a reasonable efficiency. The gain will of course vary according to the size and characteristics of the dish.



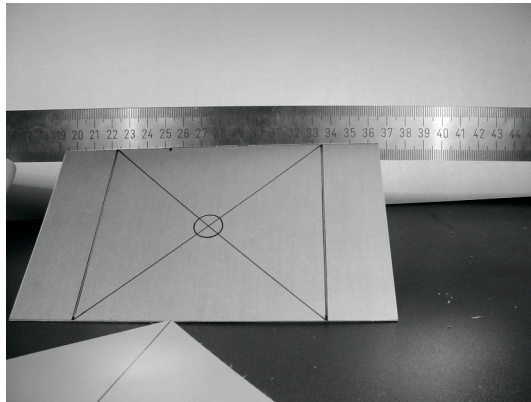
The construction is the same as the stand-alone Biquad antenna, but the shape of the metallic plate is different. The reflector has two side 'lips' which are 3 cm high, used to minimize coupling with the mounting bar of the feeder. These lips cut down radiation from the rear lobes of the biquad.



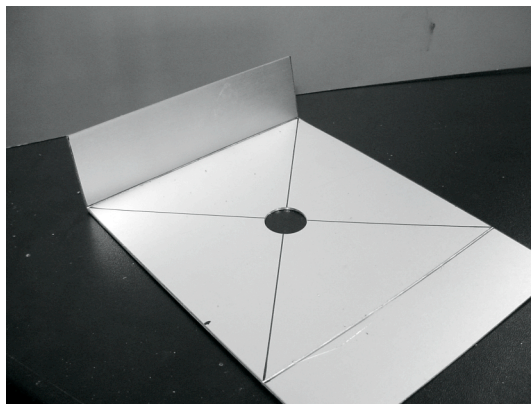
The plate is composed by three parts: a central square of 11x11 cm, and



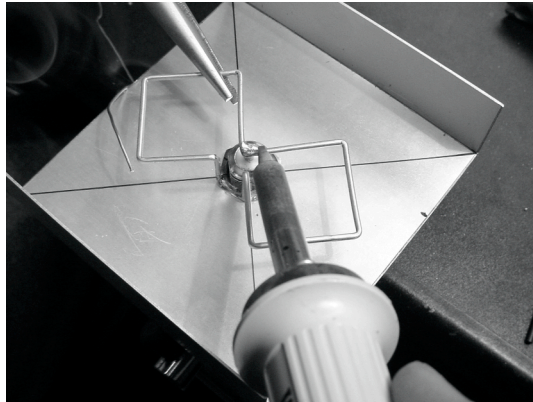
two side rectangles of 11x 3 cm.



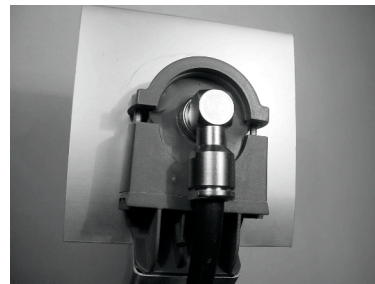
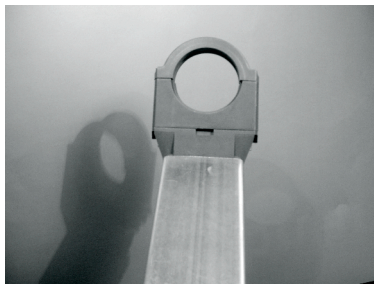
The lines between the central square and the two side rectangles should not be carved deeply on both sides with the cutter, but only on the upper side and just enough to facilitate the bending of the plate. The two lips should be folded at 90 degrees. Use the vice if needed.



The procedure to shape the wire and to solder it to the connector is the same as for the stand-alone version.



The procedure to fit the Biquad on the mounting bar may vary according to the shape of the original LNB fitting provided with the Parabolic Dish. It is usually round shaped, so it may be possible to use a rubber or plastic ring around the N connector to fix the Biquad in place.



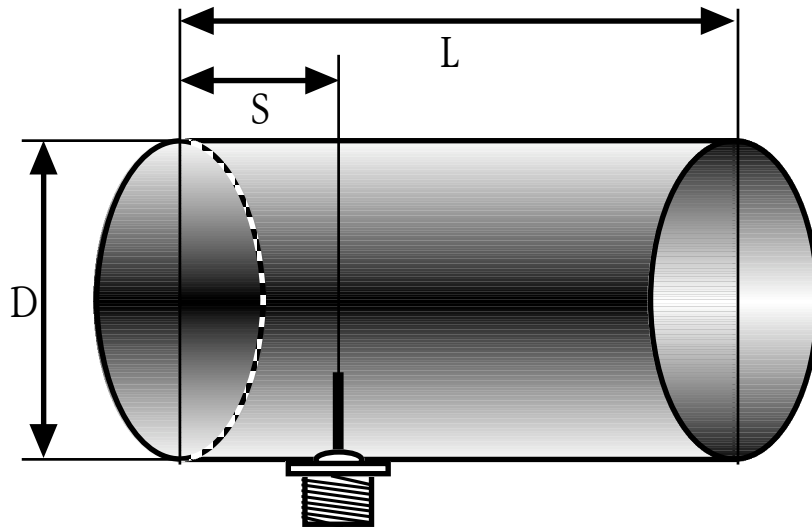
Other types of home-made directive antennas may be used as feeders for Parabolic Dishes. The important point is to match the beamwidth of the feeder with the dish size, and to place the feeder exactly in the focus of the dish.



Can antenna for 2.4 GHz

This antenna, called *Cantenna*, uses a tin can as a waveguide and a short wire soldered on an N connector as a probe for coaxial-cable-to-waveguide transition. It can be easily built at just the price of the connector, recycling a food, juice, or other tin can. It is a directive antenna, useful for short to medium distance Point-to-Point links. It may be also used as a feeder for a Parabolic Dish or Grid.

Not all the cans are good to build the antenna because there are dimension constraints:



a) The acceptable values for the diameter D of the feed are between 0.60 and 0.75 wavelength in air at the design frequency. At 2.44 GHz the wavelength λ is 12.2 cm, so the can diameter should be in the range of 7.3 - 9.2 cm.

b) The length L of the can preferably should be at least $0.75 \lambda_G$, where λ_G is the *guide wavelength* and is given by:

$$\lambda_G = \frac{\lambda}{\sqrt{1 - \left(\frac{\lambda}{1.706 D}\right)^2}}$$



For $D=7.3$ cm, we need a can of at least 56.4 cm, while for $D=9.2$ cm we need a can of at least 14.8 cm. Generally the smaller is the diameter, the longer the can should be. We will use oil cans, which have a diameter of 8.3 cm and a height of about 21 cm.

c) The probe for coaxial-cable-to-waveguide transition should be positioned at a distance S from the bottom of the can, given by:

$$S = 0.25 \lambda_G$$

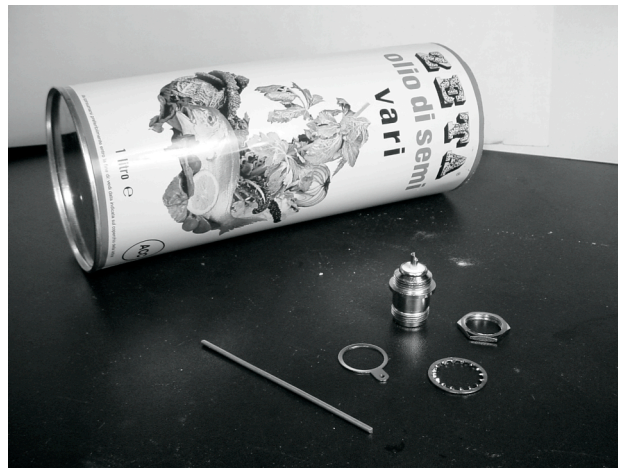
Its length should be 0.25λ , which at 2.44 GHz corresponds to 3.05 cm.

For this antenna the gain will be in the order of 10 to 14 dBi, with a beamwidth of around 60 degrees.



**Parts list:**

- one screw-on N-type female connector
- 4 cm of copper or brass wire of 2 mm of diameter
- an oil can of 8.3 cm of diameter and 21 cm of height

**Tools required:**

- can opener
- ruler
- pliers
- file for metal
- soldering iron
- solder
- drill with a set of bits for metal (with a 1.5 cm diameter bit)
- vice or clamp
- spanner or monkey wrench
- hammer
- punch



Construction:

- 1) With the can opener, remove carefully the upper part of the can.



The circular dish has a very sharp edge. Be careful in handling it! Empty the can and wash it with soap.

- 2) With the ruler, measure 6.2 cm from the bottom of the can and draw a point. Be careful to measure from the inner side of the bottom. Use a punch (or a small drill bit or a Phillips screwdriver) and a hammer to mark the point. This makes it easier to precisely drill the hole. Be careful not to change the shape of the can doing this: help yourself with a piece of wood and the vice.





3) With a small diameter drill bit, make a hole at the center of the plate. Increase the diameter of the hole using bits with an increasing diameter. The hole should fit exactly the N connector. Use the file to smooth the border of the hole and to remove the painting around it in order to ensure a better electrical contact with the connector.

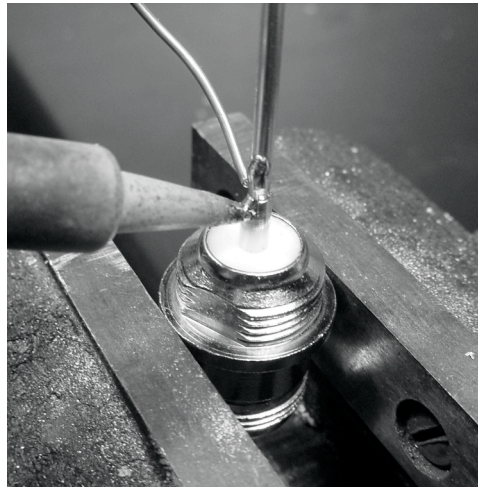


4) Smooth with the file one end of the wire. Tin the wire for around 0.5 cm at the same end helping yourself with the vice.

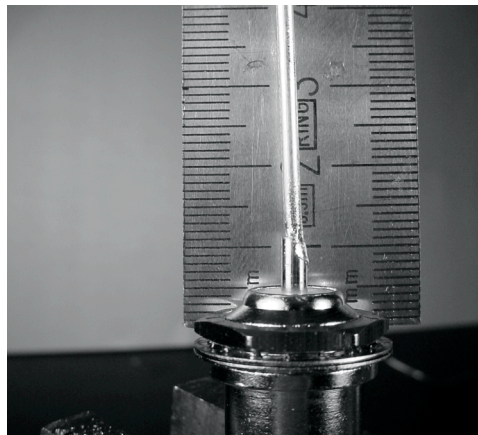




5) With the soldering iron, tin the central pin of the connector. Keeping the wire vertical with the pliers, solder its tinned side in the hole of the central pin.



6) Insert a washer and screw gently the nut on the connector. Trim the wire at 3.05 cm measured from the bottom part of the nut.





7) Unscrew the nut from the connector, leaving the washer in place. Insert the connector into the hole of the can. Screw the nut on the connector from inside the can.

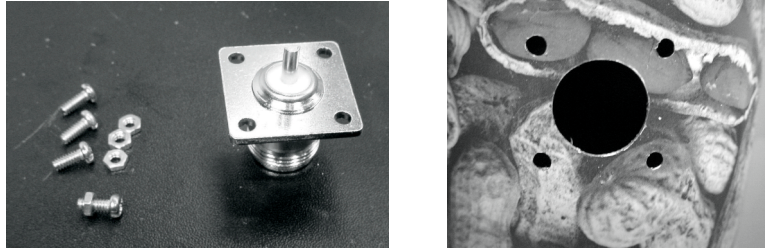


8) Use the pliers or the monkey wrench to screw firmly the nut on the connector. You are done!

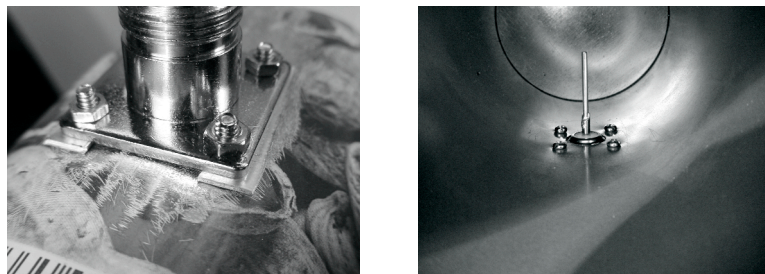




9) It is also possible to use an N-type chassis mount female connector with four-holes flange, that will make the building procedure someway more complex. In addition to the central hole, you should drill four more small holes to accommodate the screws necessary to fix the connector.



You should also use some additional washers (or thin metallic plates) in order to fit the flange on the curved surface of the can without changing its shape.



10) You can use this cantenna as a feeder for a Parabolic Dish. To match the feeder with the optimal dish size, keep in mind that the horizontal and vertical 3dB beamwidths are given by:

$$\text{Horizontal Beamwidth (degrees)} = 29.4 \frac{L}{D}$$

$$\text{Vertical Beamwidth (degrees)} = 50.0 \frac{L}{D}$$

where L and D are expressed in the same unit.



Antenna Modifications for Outdoor Use

To use the antennas outdoor, some sort of protection and waterproofing must be provided. You can use some kind of plastic box, like the ones used to store food in the refrigerator, or pipe. The material they are made of should be transparent to the microwaves at 2.4 GHz in order to avoid any attenuation of the signal or modification of the antenna's characteristics. You may check this in two ways:

- 1) Testing if the insertion of the protective plastic around the antenna modifies in any way the signal's strength in an existing radiolink.
- 2) Checking if the plastic heats when placed in a microwave oven at the maximum power for a couple of minutes. Be very careful not to damage the oven and always insert a glass with water in the oven so that it will not run empty.



Waterproofing can be obtained sealing carefully the plastic box or pipe on the antenna with hot glue or silicone.