Double Biquad Antenna

This page contains details on building a double biquad antenna with approx 13dBi gain.

Background

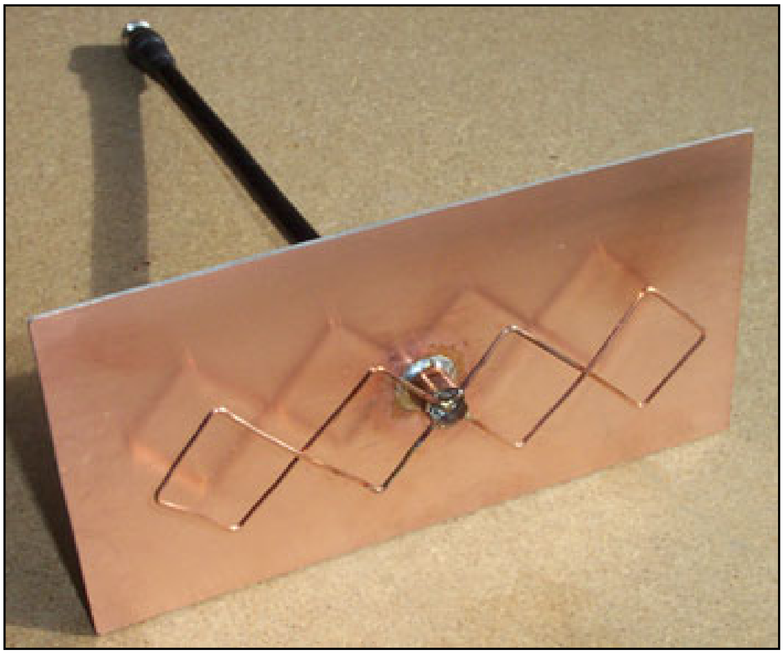
Having experimented with a number of biquad antennas (construction details here), I have found them to be relatively easy to contruct, reliable, and good performers, with about 11 dBi gain.

A number of websites showed a variation of the biquad, with the reflector being double the size, and with the element having twice as many sections.

I decided to make a double biquad, to see how the gain compared to that of a biquad.

Construction

I made a double biquad using exactly the same construction techniques as described on my Biquad Antenna Construction page, except the rear reflector is 110x220mm, and the element is double the size.



double biquad

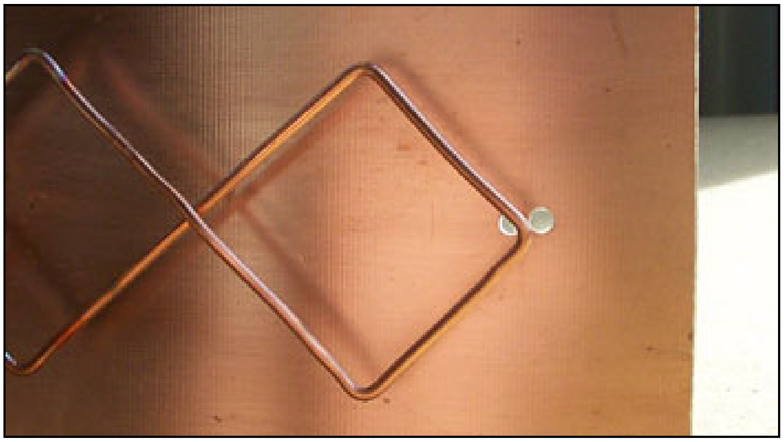
Note that the element wires do not touch where they cross over, but are separated with a gap of approx 1-2mm.

To provide some more robustness, and to ensure the element doesn't move, I added some spaces at each end of the element.

The spacers are made from a small section cut from a hollow reticulation riser, and attached to the reflector and element using a small wire tie. Measure and cut the spacers to be 14.5mm long, as this should result in the element being the correct 15mm from the reflector.

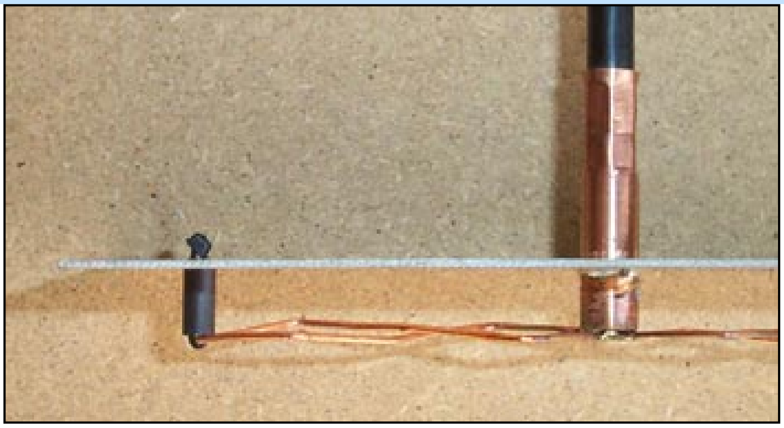
parts required for the spacers

Drill two small holes in the reflector, in line with each end of the element. The holes must be large enough to allow the wire tie to pass through them.



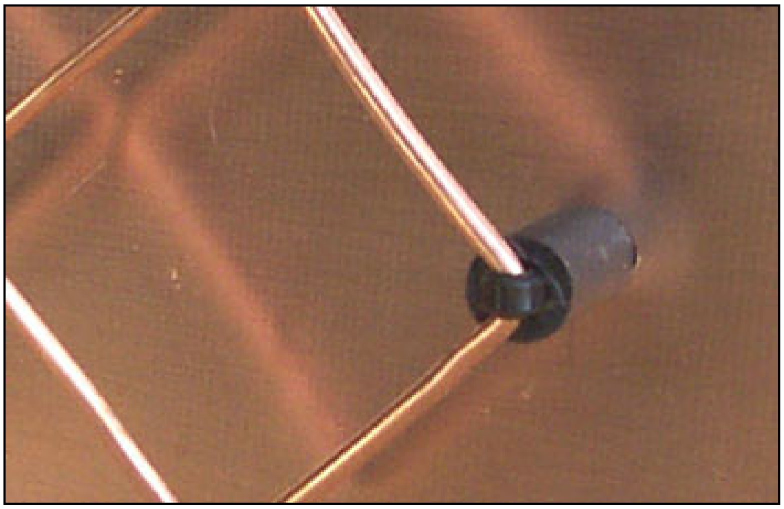
two holes in the reflector for the cable tie

The spacers are attached by passing the wire tie through one of the holes in the reflector, through the tube, looped around the element, and then passed through the tube again, and through the other hole in the reflector.



spacer installed

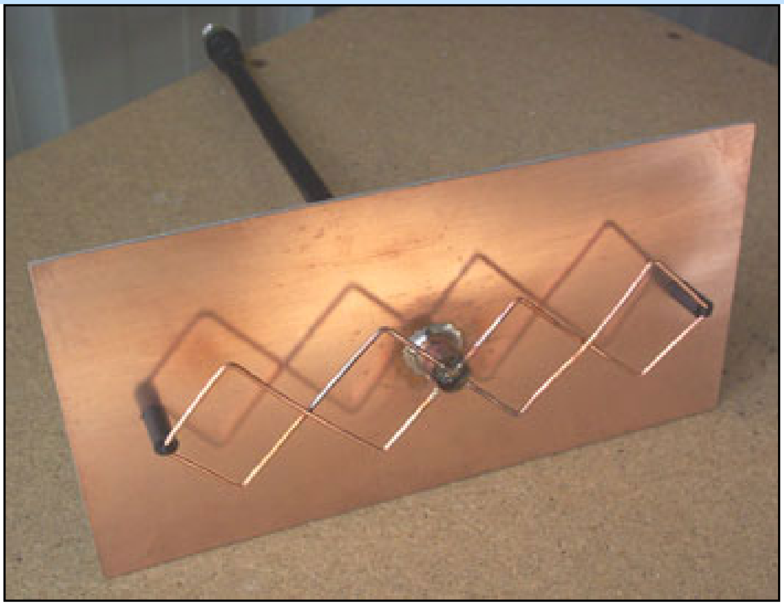
The spacers will ensure the posititioning of the element relative to the reflector will not change, and also means the antenna is less likely to be damaged while in transit or while being handled.



detail of spacer

Note that you can make spacers out of any non-metallic material, providing it does not absorb microwaves.

As with the biquad antenna, if you intend to use one of these outdoors, I'd recommend you place it into a weather-proof enclosure, to prevent corrosion, and to prevent water ingress into the coax.



completed double biquad

Testing

To determine the difference in gain between a biquad and the double biquad, some tests were performed, with the signal, noise and SNR recorded.

antenna	SNR (dB)	signal (dBm)	noise (dBm)
biquad	43	-58	-101
double biquad	45	-56	-101

The test results indicate that the gain of the double biquad is approx 2dBi higher than that of the biquad, which is a significant improvement (as 3dBi is a doubling of signal).

As the biquad has a gain of 11-12dBi, this means the double biquad has a gain of 13-14dBi, so it's a pretty good performer for something that's relatively easy to build.

These results are similar to those obtained by other people who have made double biquads.

References

Biquad Antenna Construction
Photos of a Double BiQuad
Double Double Quad

last updated 10 Sep 2004

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Biquad Antenna Construction

This page details the construction of a biquad antenna. The biquad antenna is easy to build, and provides a reliable 11dBi gain, with a fairly wide beamwidth.

Background

I've done quite a bit of experimentation and testing with various homemade dipoles for 24dBi Conifer dishes, and have managed to increase the performance of the dish.

Trevor Marshall has a webpage with information about using a biquad as a feed on a Primestar satellite dish, with very good results. I decided to try using a biquad as a feed on a 24dBi Conifer dish, to see if I could improve the performance of it of the dish.

Note that the photos on Trevor Marshall's webpage do not clearly show the construction of the biquad - particularly the way in which the quad is attached to the coax. Numerous people (including myself) have constructed biquads incorrectly, based on his photos, and found that they perform very poorly.
Use the photos of my biquad below, and refer to the websites listed in the references section at the bottom of this page for more information on the correct construction of the biquad.

Parts Required

I used the following bits and pieces:

- 110x110mm square section of blank PCB
- 50mm length of 1/2" copper pipe
- short length of CNT-400 or LMR-400 low loss coax (~300mm long)
- 250mm of 2.5mm^2 copper wire (approx 1.5mm diameter)
- N connector

Note that you don't have to use blank PCB for the reflector. You can use any material that's electrically conductive, can be electrically connected to the coax braid, and will reflect microwaves (ie, any metal plate will do fine).

- [RedHat 7.3 on Dell Optiplex GXi]
- [RedHat 7.3 on PPro VS440FX]
- [RedHat 9.0 on Celeron 466]

site search

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I've also heard of people using CDROM as the reflector, as the foil on it will certainly reflect microwaves.

Reflector

Cut a square piece of blank printed circuit board, 110x110mm.

Note that Trevor Marshall recommends a size of 123x123mm if using the biquad as a stand-alone antenna, while 110x110 is optimal if using it as a feed for a large dish.
He also recommends attaching some lips to two sides of the reflector, to reduce radiation from the rear lobes.

Use some steel wool to remove any tarnish and polish it up. Cleaning the copper in this way will make it easier to solder.

blank printed circuit board

Cut a 50mm section of copper pipe, and file both ends smooth. Using some sandpaper and/or some files, polish up the copper pipe (including the inside of the copper pipe, to ensure a good connection with the coax braid).

the dimensions of the copper pipe

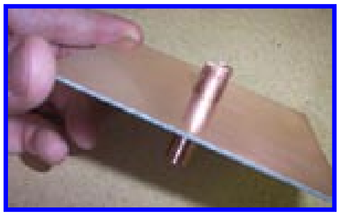
Cut a notch into one end of the copper pipe, removing approx 2mm from half the circumference.

a short secion of copper pipe, notched at one end

Drill a hole in the centre of the blank PCB so that the copper pipe is a tight fit in the hole. I found a reamer to be very useful for enlarging the hole to the correct size.

making a hole in the centre

Insert the copper pipe into the hole, with the notched end on the copper side of the blank PCB. The copper pipe should be protruding approx 16mm through the hole, measured on the copper side of the PCB.



insert the copper pipe into the reflector

Solder the copper pipe to the PCB, to ensure a good physical and electrical connection.

solder the copper pipe to the PCB

Quite a bit of heat is needed, due to the thickness of the copper pipe, and an electrical soldering iron probably won't be able to deliver sufficent heat. I found a small gas torch works quite well.

Making the Element

The element is made from a length of copper wire, bent into the appropriate shape.

Note that the length of each "side" should be as close to 30.5mm as possible (measured from the centre of the copper wire to the centre of the copper wire), which is a quarter of a wavelength at 2.4GHz *the shape and dimensions of the element*

I had some offcuts of electrical power cable lying around, and found that 2.5mm^2 power cable had a diameter of approx 1.6mm - a little bigger than the 1.2mm that Trevor Marshall specifies, but didn't think it would make a significant difference to the performance of the biquad.

recycling power cable offcuts

Remove the insulation, measure and cut a 244mm length the copper wire, and straighten it as best as you can.

straighten the wire

Measure the mid-point of the wire, and make a 90 degree bend. The bend should be quite sharp and pronounced.

90 degree bend

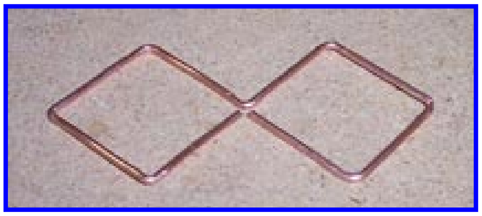
Measure the midpoints of each half, and make two more 90 degree bends in the wire, so that it looks like that shown in the photo below.

another two bends

Once again, measure the midpoints of each section, and make some more 90 degree bends, resulting in what is shown below.

bend it some more...

Do the same to the other side, resulting in the biquad shape.

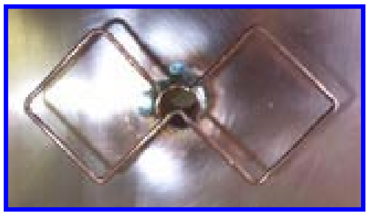


make it symetrical...

Clean up all your bends, and ensure each side of the element is as straight as possible, and as close to 30.5mm as possible.
Note that you may need to trim a small amount off each end of the wire to achieve this.

Assembly

The element must now be attached to the reflector. Note that only the two "ends" of the copper wire are to be attached to the copper pipe - the centre of the copper wire must not touch the copper pipe (hence the notch which was cut into the end of the copper pipe.
The copper wire should be approximately 15mm away from the reflector.



the element soldered onto the copper pipe

Strip approx 30mm of the outer sheath from the end of the coax.

strip the outer sheath

Fold the braid back over the outer sheath, and trim the centre conductor, so that about 4mm is protruding.

fold the braid back, trim the centre conductor

Insert the braid into the copper pipe, so that the end of the centre conductor lines up with the extreme end of the copper pipe, and solder the centre of the element to it, ensuring the centre of the element is not in contact with the copper pipe. Refer to some of the additional photos below for details.

solder the centre conductor to the element

another view

I used a coax crimper to crimp the end of the copper pipe onto the coax. This ensures that the coax would not move inside the copper pipe.

the copper pipe crimped onto the coax

the completed biquad

Now terminate the other end of the coax with an N connector.

If desired, you can add spacers at each end of the element, to ensure the element doesn't move in relation to the reflector. Refer to my double biquad page for more details on making spacers to support the element.

If you intend to mount the biquad outside, I'd recommend you place it into a weather-proof enclosure, to prevent corrosion, and to prevent water ingress into the coax. Numerous people have used small tuppaware containers successfully.

This can be achieved by drilling a hole in one side of the container, and pass the coax tail through the hole, leaving the biquad itself inside the container. Seal up the hole for the coax with some silicone, and your biquad should be protected against the elements.

another view of the completed biquad

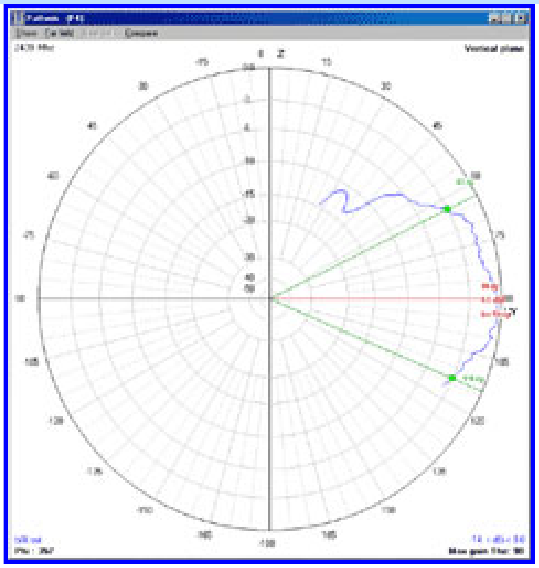
Testing

Some very rough initial testing using the biquad as a feed on a 24dBi Conifer dish looks very promising, with the signal strength being at least as as good as my homemade Conifer dipole (I was holding the biquad at approximately the focal point of the dish, and hadn't even removed the Conifer dipole).

I also managed to get a marginal link to a 180 degree waveguide on an access point 10km away, using only the biquad by itself, connected to a 30mW RoamAbout wireless card.

Some more detailed testing with multiple antennas, including the biquad shown above, indicates the biquad has a gain of approx 11-12dBi.

A friend has access to some antenna test equipment, and performed some tests on the biquad featured on this page.
The azimuth plot of the biquad is shown below, and shows a 3dB beamwidth of about 50 degrees.



azimuth plot of the biquad

Variations

A number of people have suggested the spacing between the element and the rear reflector should be a 1/4 wavelength (ie, 30.5mm) instead of 15mm. However, test results (such as [these]) indicate the SWR of the biquad is minimised when the spacing is about 15-17mm.
Increasing the spacing to 30.5mm increases the SWR significantly, thus reducing the efficiency of the biquad.

For a higher-gain variation of the biquad that's virtually just as easy to build, have a look at the [double biquad].

Usage

When using a biquad to establish a link to another wireless device, you should ensure the polarisation of the biquad is the same as the antenna you are connecting to.
Similarily, if establishing a link with two biquads, ensure they are both oriented for the same polarisation.
Failing to match the polarisation will result in significant signal loss.

vertically polarised *horizontally polarised*

Changing the polarisation is just a matter of rotating the entire biquad antenna by 90 degrees.

The biquad antenna is not particularly directional, but has a fairly wide beamwidth.
The 3dB beamwidth for a biquad (without side lips) is typically about 40-50 degrees, thus making it ideal for any applications where you want fairly wide coverage.

The relatively wide beamwidth also makes a biquad very suitable for war-driving and stumbling, allowing you to pick up signals without having to align the antenna directly with the signal source.

While a directional antenna, such as a Conifer dish (3dB beamwidth of a 24dBi Conifer dish is approx 7 degrees), is better suited for point-to-point links, the narrow beamwidth of a Conifer dish requires more precision when aligning the antennas (the narrower the beamwidth, the less susceptible it will be to interferance from other sources). An antenna with a wider beamwidth, such as a biquad, doesn't require the same precision for alignment, thus making it easier to get a link working.

References

Trevor Marshall's BiQuad 802.11b Antenna

Simple Double-Quad Antenna

Reseau Citoyen: BiQuad

Lincomatic's Homebrew WiFi Antennae

last updated 20 Oct 2004

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Modifying Conifer Antennas for Wireless Networking part 1

(first published May 2002, revised June 2002)

This page details a method for constructing a new dipole for a Conifer dish, resulting in improved performance over the more common dipole modification.

Contents:

Conifer (ex Galaxy) Antennas

The antennas we're using are made by Conifer (now known by the name of their parent company, Andrew Corporation), and were used in Australia by a pay-tv company called Galaxy.
Galaxy went out of business several years ago, so there are a lot of un-used Conifer antennas on people's roofs in Australia.

The most common Conifer antenna used by Galaxy is the 18dBi grid, while the 24dBi grid is a little less common. Note that both the 18dBi and 24dBi grids use an identical feedhorn, so this page is applicable for both.

18dBi and 24dBi ex-Galaxy antennas made by Conifer, with a 30cm ruler (bottom right) for scale

However, the Conifer antennas used by Galaxy were designed to operate at a different frequency than wireless networking, and have a down-convertor integrated in the feedhorn.

They need to be modified before they can be used for 802.11b wireless networking, and this page describes one way to modify them, achieving very good results.

- RedHat 7.3 on Dell Optiplex GXi
- RedHat 7.3 on PPro VS440FX
- RedHat 9.0 on Celeron 466

an 18dBi Conifer (as installed by Galaxy)

Background

Numerous people have posted guides on modifying Conifer antennas (ex-Galaxy) for use with wireless networking. Most of these guides show how to disasemble the feedhorn, cut off the end of the down-converter PCB, and solder coax onto the PCB dipole.

the most common mod - coax soldered to the cut pcb

Of all the sites out there, ChrisK's page on his Galaxy modification was the most interesting, as he rebuilt the dipole from scratch, ensuring the measurements of the dipole and balun were as accurate as possible for operation at 2.4GHz.

ChrisK based his dipole on a design shown on this page, and Marcus and myself believed we could construct similar or better dipoles, and decided to use a brass plate for the dipole (instead of the thin brass tube which ChrisK has used).

To ensure the correct balun impedance of 50 ohms, the ratio of the inner diameter of the copper tube to the outer diameter of the brass rod should be approx 2.3.

The important dimensions are:

- length of the dipole is 1/2 wavelength
- length of the balun is 1/4 wavelength
- ratio of inner diameter of copper tube to outer diameter of brass rod

The 802.11b standard uses 2.412MHz to 2.484MHz frequency range, so at the centre of that frequency range, 1/2 wavelength is 61mm, and 1/4 wavelength is 30.5mm.

Below is a cut-away diagram showing the parts used in the construction of the dipole.

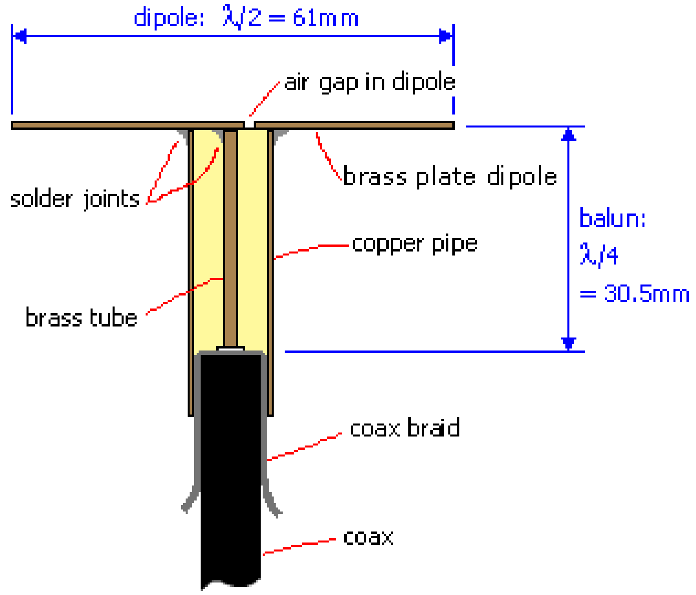

diagram showing components fitted together

Parts Required

The materials we used to perform this modification:

- Conifer (ex Galaxy) antenna
- low-loss coax (such as LMR-400 or CNT-400)
- 50mm of copper pipe (~10mm internal diameter)
- 61mm of flat brass bar (~12mm wide by ~0.5mm thick)
- 30.5mm of brass pipe (~4-4.5mm outer diameter)
- female n-connector

the raw materials: copper pipe, brass tube, brass plate

Most Bunnings and Mitre10 hardware stores should stock these materials - ask at the trade counter if you can't find them.

The brass plate I used is 12mm wide, and 0.6mm thick, while the copper pipe has an internal diameter of 10.8mm, and the brass tube is labelled as "3/16 round brass - stock no 129" with an external diameter of 4.5mm.
This means the ratio of the inner diameter of the copper to the outer diameter of the brass is 10.8/4.5=2.4, which is close enough to the required ratio of 2.3.

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last updated 20 Oct 2004

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