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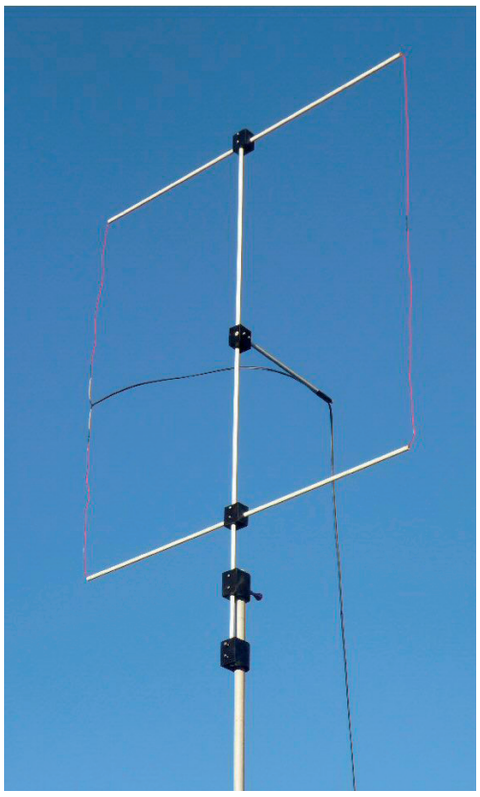
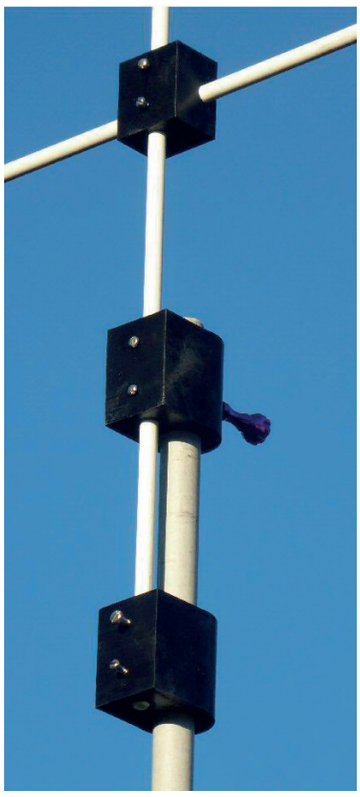




4m band quad with twin feeder – a universal VHF antenna?

Jonathan Hare G1EXG offers a simple VHF antenna that can be made to work on multiple bands.

A homemade lightweight yet strong vertically polarised 70MHz quad is described that also works well from 50MHz to the top of the VHF FM band. Unusually for a VHF antenna the quad is fed with 95Ω twin feeder [**1**]. This makes the whole antenna system very much lighter than one made with coax cable. The antenna also works down to 40MHz (8m band) and so may be a useful 'get you on the air' antenna if permission for this band is granted in the future [**2**]. This is also an interesting antenna to listen to distant FM radio stations, which can be a way of monitoring VHF band conditions. The antenna should also cover the aircraft band.

Many quad designs have been published over the years, this version is not about creating a high gain antenna for one band, rather it's about creating a versatile antenna that can be used for multiple types of VHF receiving and transmitting purposes.

Limited space for antennas

My antennas are limited to what I can put up in my small back yard and house side wall. I have two mast systems, one of which is a 15m telescopic fibre mast that is only secured at the base. I don't have much room for guys so ideally the antenna and feeder need to be very lightweight for me to put the antenna at full height. Other antenna arrays must be raised to less than 15m depending on weight and wind, etc.

Noise on VHF

The last few years has seen the noise grow on all bands and start to extend up to VHF. 2m FM is OK but SSB is almost a non-starter here in my part of Brighton on some beam headings. The noise on 6m and 4m is also a problem and I have tried various antennas to try to reduce the noise pick up. Last year I wrote about an end-fire array [**3**] that I had built for 2m, 4m and 10m and in all these antennas the open wire feed system showed lower noise compared to a coax fed system (although there were losses at VHF). It seems that a balanced antenna using open wire feeder is often better than coax [3].

Like the dipole the quad has a figure of eight pattern (but the quad is slightly narrower due to its slightly greater gain). On 4m where the antenna is a full-sized quad, it will be most sensitive to signals arriving flat-on to the square i.e. where the waves arriving see the whole square of the loop. It is least sensitive side-on (the antenna's null). The balanced feeder and ATU will help to lower noise pick-up by the feeder, but you can also lower the received noise by turning the antenna to arrange for the null to be in the direction of your local noise (assuming there is just one source of noise, of course).

95Ω twin feeder

Many quad designs use a quarter wave 75Ω Q-section (quarter wavelength of 75Ω cable) to match the ca. 100Ω of the quad to a 50Ω line. As noted above I have used quality 95Ω twin feeder in this design which will, of course, give a very good match to the quad on 4m.

The twin feeder came from Spectrum Communications [1] and is a very nicely made cable having PTFE insulated wires within a tough plastic outer. The separation of the parallel wires is quite close, about 5mm or so. The company has it custom made and sells it in 20m lengths. The feeder has impressive HF specifications [1] and they also claim the feeder provides very low noise on HF. On this basis, I decided to try it out at VHF.

When the quad is used with twin feeder and with a balanced tuner you have an antenna that can cover a much greater range of frequencies than when using a relatively narrow bandwidth Q-section. 20m of twin feeder is lightweight (ca. 0.5kg) compared to an equivalent run of cable such as mini-8 (ca. 1kg), for example.

As my antenna is often at full height (15m) I used the full 20m length of twin feeder but ideally, at VHF, you would want to use the minimum amount to reduce losses to a minimum.

Polarisation

The setup shown here has the twin feeder connected to one of the vertical sides of the quad square. On 70MHz it will therefore produce a vertically polarised signal. I am not sure how the polarisation may change when using the antenna far from 70MHz, say up at the top end of the FM band etc.

Fibre tubes

I used fibre tubes which are very light, stiff and have great strength [**4**]. I bought a pack of ten 3m long 10mm diameter tubes for about £80 on eBay a few years ago. They are often used as rail supports for hanging rugs or tapestries [4].

Fig. 2: General arrangement of antenna. Figs 3 and 4: Internal views showing the construction of the ATU.

I have used them as spreaders for quads, delta loops and for the smaller receiving loops. Use tubes rather than rods, as the quad wire runs along inside two of the tubes. For this antenna I used: 1 x 30cm long tube, 2 x 1m long tube and 1 x 1.5m long fibre tubes.

Warning: cheap fibre tubes and rods are often uncoated, so take great care handling them as it's easy to get small glass fibres in your fingers. Use gloves when you handle and when you cut them. However, if you spray them after cutting, with a coat or two of clear acrylic paint, they are safe to handle without gloves.

A Dremel drill with a ceramic-glass cutter attachment will grind through these tubes very effectively, so it's easy to cut them down. Spray water on the cutting disc as you cut through.

The diagram, **Fig. 1**, shows the general arrangement.

3D printed support parts

I made 3D-printed holders / clamps for the fibre poles, each with two self-tap screw holes to secure them on to the tubes. Details of the 3D-printed parts are on my website [**5**]. There are three identical square clamps ('a' on the diagram) to secure the 1m poles to the 1.5m tube. Two of these hold the two 1m tubes while the third holds a short 30cm feeder support tube. I also printed two holders ('b' on the diagram), which go on the bottom of the 1.5m fibre tube and which fit the top pole (ca. 24mm diameter) of my 15m mast. These two mast support brackets are fitted about 25cm apart and make a secure and professional looking mast clamp system. I used 4mm diameter threaded butterfly bolts to secure these to the top of the mast pole (no need to thread the plastic clamps, just drill out my printed hole with a smaller pilot hole and screw in the butterfly bolts). The 1.5m pole is secured to these clamps using self-tap screws.

I used PLA for the 3D-printed parts and find they work well for my experimental antennas. If you were planning a permanent device, you might want to use ASA (similar material to that used in plastic drainpipes), which has better UV properties and will be less likely to wilt or distort in the summer heat etc.

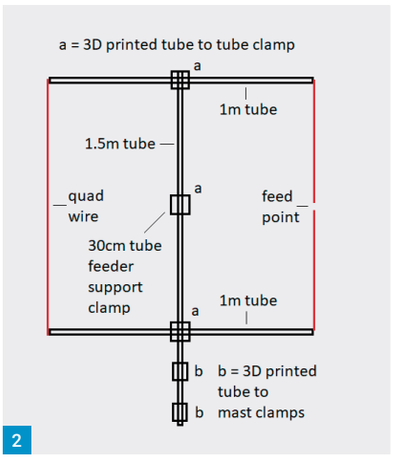
Assembly

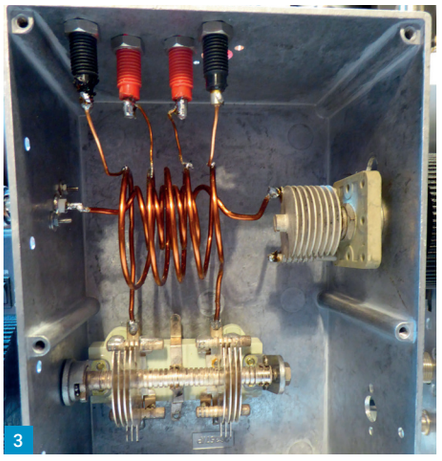
The quad loop can be made from enamelled copper wire but ordinary plastic-coated hook up wire (e.g. 16 strand) is easier to handle. Cut a 4.2m length, which is slightly longer than a full wave for 70MHz, if necessary, you can cut it down later. Push on all five of the 3D-printed holders onto the 1.5m tube and space them out so the mast supports (b) are at one end (spaced about 25cm) and the top quad tube to tube support (a) is at the other end. The second support (a) goes between the two quad tubes (see diagram, Fig. 1, and [5]). The third quad support (a) goes about 1m down from top one. You can move the exact position of the lower (third) quad holder later to tighten up the quad loop.

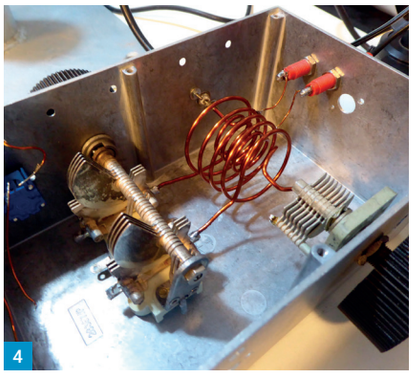
At first only lightly tighten the self-tap screws to hold the tubes in position. At the end of the construction, you can tighten them more securely. Cut about 7.5cm of the outer insulation away from the twin feeder and splay the two wires. Remove 1cm of the insulation from these and tin the wires.

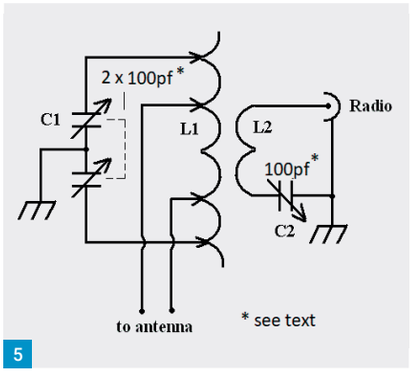
With the basic H-shape assembled, thread the quad wire through the two 1m tubes so the two ends meet the twin feeder on one side. Solder in place and adjust the feeder so it is halfway down one side. Use liquid tape waterproofing compound to seal everything. Then adjust the lower (third) support to tighten the quad a little so it is a neat square shape, it does not need to be very tight.

The short fibre tube in the middle (between the two quad holders) points outward from the plane of the quad (see photos and **Fig. 2**). I taped the twin feeder to this at a suitable place along the feeder to secure and positioned it away from the quad loop wire and ran it down the mast.









Balanced ATU

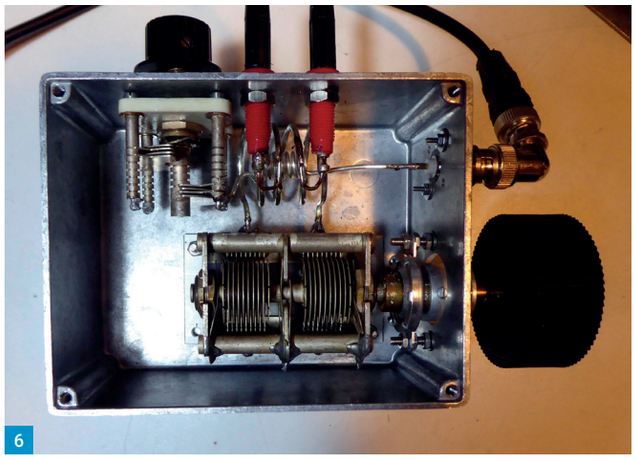
The 95Ω twin feeder will match the ca. 100Ω impedance of the quad at resonance (i.e. at 70MHz) very well. This should therefore provide less loss than when using 300Ω slotted feeder for the 20m length used here. The ATU will then transform the impedance at the shack end of the twin feeder to a 50Ω match for your receiver / transceiver.

The basic balanced ATU, see photos **Figs 3** and **4** and circuit **Fig. 5**, is very simple, and I have used scaled versions on other bands with great success [3]. I love balanced antennas. Last year I wrote about end-fire array antennas for 2m, 4m and 10m bands [3]; they are easy to tune, and common mode noise is balanced out. I believe the same is true with this twin feeder fed VHF quad.

Note: to get the best out of this antenna you need to make sure you use a true balanced ATU like the one described here. The result is that you will have a wideband antenna that matches very well and because of the twin feeder you get the best possible reduction of noise.

ATU construction

It's good to build the ATU into a diecast metal box and keep all connections as short as possible. Ideally arrange everything for short RF connections to coils, sockets etc. rather than arranging things so it looks nicely laid out from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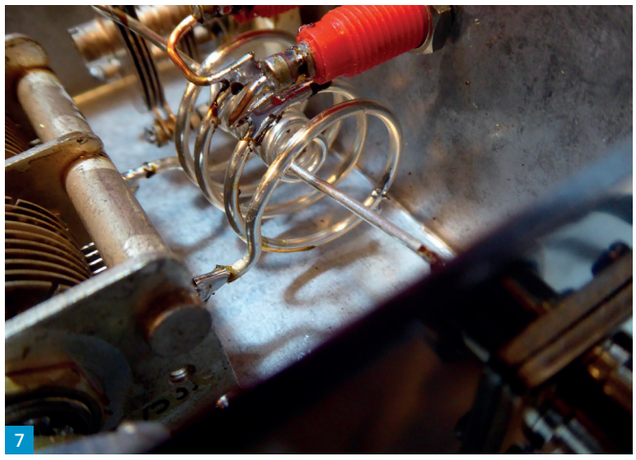
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Figs 6 and 7: Internal views of balanced ATU.

the front. I used capacitors I happened to have and it's unlikely you will have exactly the same type. The beauty of the design is that you build it around the capacitors you can get.

Information for my first ATU:

C1 is a dual-gang type, each gang being around 75pF. C2 is a single gang type of about 100pF.

L1 and L2 are made to suit the caps you can get / have. The ones shown here are a guide to start with. If in the development of your ATU you aim for 'larger caps' and 'smaller coils' you will get a wider frequency coverage.

L1 = five turns ca. 40mm diameter coil made from 1.5 - 2mm enamelled copper wire (if possible, use silver plated copper wire)

L2 = four turns ca. 15mm diameter coil within L1 made from 1.5 - 2mm enamelled copper wire (if possible, use silver plated copper wire)

L1 is tapped either side of centre i.e. at 2 and 4 turns

My first version of the ATU with the coils and capacitor information as above (see photos, **Figs 6** and **7**) is made with 2mm enamelled copper wire and it tunes from about 30 - 75MHz. The second version is smaller and was designed for VHF FM experiments. I used silver coated copper wire, it tunes from about 70 - 150MHz.

My MFJ-269 antenna analyser shows the ATUs can tune the antenna over these range of frequencies, often with an SWR of less than 1.5:1. Although on receive it's hard to notice any improvement in reception with SWRs better than 2:1. It is possible that on receive, lower SWRs may help maintain balance and therefore improve noise cancellation etc.

Results

My first attempt at making the ATU worked well on 70MHz but it would not go down to 50MHz. So, I made a few versions of the coils to try and give a greater range. Eventually I had to swap the dual capacitor (C1) for a slightly larger value one to get the best range. A second version of the ATU covers 50 - 150MHz so will work for the FM and aircraft band.

First adjust / peak C1 for resonance and maximum signal then adjust C2 for best SWR. You may need to re-adjust both again to home-in on the best match.

I can get near perfect 1:1 VSWR on both 50 and 70MHz but other factors such as antenna height, nearby objects etc will affect your setup. With the later changes to my ATU I did find I had to reduce the length of the quad wire by 25cm or so to get a perfect SWR on 70MHz.

I have had no problems at all using the ATUs on transmit with about 40 watts on 50 or 70MHz. I tend to tune the ATUs on low power (few watts) first, then once the SWR is low, increase the power.

As stated above for my first ATU L1 is tapped either side of the centre at 2 and 4 turns. I also added tap points at 1 and 5 turns but so far, I have never needed these alternative points to match correctly. Tests with this antenna show it is about as good as my 2-element end-fire array on 70MHz but this is probably because the lightweight quad can more easily be put at full height. Height being a big positive factor at VHF.

I was surprised how well the 70MHz quad worked on 50MHz. I am sure this is partly due to using the 95Ω open wire feeder. Despite the mismatch on 50MHz the losses will be less with twin feeder than, say, trying to load up a 70MHz quad (with Q-section) using 50Ω coax on a standard un-balanced ATU.

The antenna works quite well on the VHF FM band. FM radio stations are usually very strong and even my IC-R7000 struggles a bit to separate FM radio stations that are relatively close in frequency. FM discriminators tend to lock into the strongest signal on, or near, to frequency you are tuned too. So, if you want to listen to more distant stations, it's worth rotating the quad so the nearer / stronger stations are in the null of the antenna (in line with the square).

I have not tried using 300Ω slotted feeder as the 95Ω worked so well, but it should also provide a wide matching range when used with the balanced ATU. At 50MHz the quad is likely to have a lower impedance than ca. 100Ω 70MHz quad impedance. The 95Ω feeder will probably provide a slightly better match than when using 300Ω slotted feeder.

There is no doubt an ATU like this is fairly lossy at VHF. I used silver plated copper wire in my second ATU, but so far, I have not seen much difference in performance between the two.

I cleaned up (and thoroughly dried and re-oiled) the tuning capacitors in an ultrasonic bath before using them in my ATUs.

I tried replacing the 20m twin feeder with 20m of mini-8 coax (and a Q-section) at 70MHz, and it did provide less loss, but the advantage of the twin feeder, with its very wide band and low noise response, makes the twin feeder and an ATU a much more versatile antenna – which is why I titled this article a *Universal VHF Antenna*.

Acknowledgements

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References and links

- [1] Spectrum Communications Noise Cancelling 95Ω Twin Feeder see: **www.spectrumcomms.co.uk**
- [2] 'The 8m band', Practical Wireless, September 2024, page 51 but also see RadCom, RSGB May 2022, page 8.
- [3] 10m band end-fire array antenna, Practical Wireless, Sept. 2024.
- [4] For fibre tubes try searching for 'Roman blind tubes / poles'.
- [5] My 3D printing page: **www.creative-science.org.uk/3D.html**