Antenna Workshop

Len Paget GM0ONX has developed a taste for chasing DX, but having a small garden limits his options for beam antennas. Like many readers a full sized tri-bander will not fit in without hanging over his neighbour's garden.

Now although I'm fortunate enough to have really understanding neighbours who are generally uncomplaining and even supportive of the activates of the 'radio nutter' next door, I didn't really wish to impose further on their goodwill by asking for 'over-flight rights' for an antenna. One solution I've tried was a mini beam, of which there are a number of descent ones on the market these days.

Most of the mini beams I tried had problems with mediocre performance, a narrow standing wave ratio (s.w.r.) bandwidth, poor front/back ratios and nasty tendencies to change resonant frequency during heavy rain. I felt that, surely a better solution had to exist!

Now the term 'small' is not usually associated with a quad-loop antenna, but what is generally overlooked is that a full

size two-element h.f. quad only requires about five metres of horizontal space - about the same space as most mini beams. Unfortunately, for me such antennas also require the same amount of vertical space, which leads to my undoing. There's no way I could tilt over my mast with such a tall 'rotary washing line' on the top.

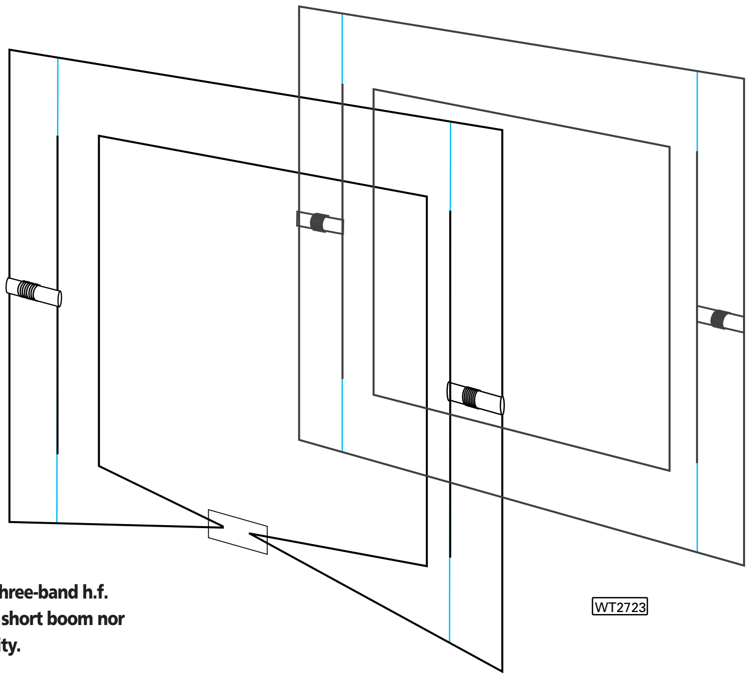


Fig. 1: The skeleton layout of the three-band h.f. cubical quad antenna. Neither the short boom nor the spider are shown here for clarity.

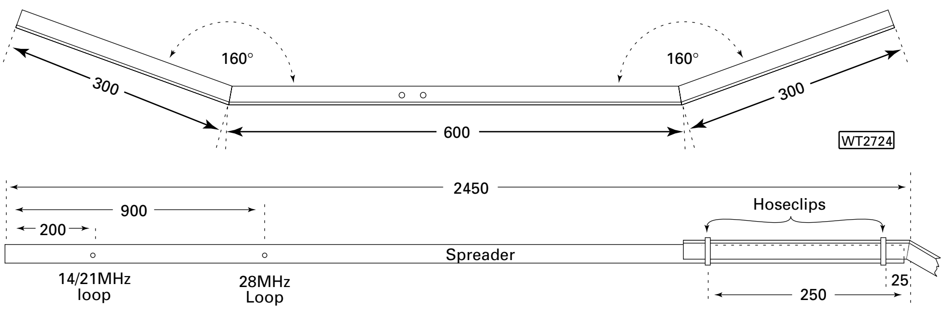


Fig. 2: Each end of the spider consists of two crossed arms (above) and four spreaders made as described in text.

Trawling A Solution

Trawling through the Internet for a solution to my problem I eventually found a reference to design for a compact quad by **J. M. Hawkes 9H1GL** originally published in *Radcom* in April 1984. This antenna is a fairly standard spider quad loop antenna with full wavelength loops on 21 and 28MHz, but on 14MHz the 21MHz element also acts 2λ/3 loop and is linear loaded via a coaxial trap. With sides of about 3.6m, it looked as if it would be possible to fit it and its tilted-over mast into the garden with millimetres to spare.

The simplified general layout of the antenna is shown in **Fig. 1**, the elements are constructed from 1mm pvc covered wire for no other reason than that's what I had to hand. The standard formula of (306.32/f)m is a good starting point for construction calculation. This formula, gives a loop length of 14.43m for the 21MHz driven loop and 10.75m for the 28MHz one.

The reflector uses the standard (313.94/f)m formula as its starting point, which gives a length of 14.79m for the 21MHz element and 11.02m for the 28MHz element. The final length after trimming for resonance will be dependent on the wire type, diameter and whether it's insulated or bare.

The spider for the quad-loop is constructed from four pieces of 1.2m long 25x25mm (5mm thick) angle iron formed as shown in **Fig. 2** and the photograph of **Fig. 3**. This is the key component of the antenna and must be constructed correctly, so it's worth getting a blacksmith to manufacture it if you don't

● **Fig. 4: The completed spider and boom assembled with only the spreaders needing to be fitted (see text).**

● **Fig. 5: When making the spreaders from plastic water pipe, each is reinforced with a suitable bamboo 'cane'. (See text for more details).**

have the skills yourself. (But I've found that most radio clubs have someone with the necessary skills and equipment to do the job).

Two sets of holes are drilled in each bracket offset so that the boom will sit in the centre of the spider. The brackets are fixed 90° to each other and attached to a 760 by 50mm aluminium boom by four 50mm car exhaust clamps as shown in **Fig. 4**. The whole assembly is then painted with Hammerite paint to protect it from the weather.

Suitable Spreaders

The biggest problem with making any quad antenna is sourcing suitable spreaders. The usual glass fibre reinforced material (g.r.p.) poles are expensive when you have to buy eight of them and dowelling and bamboo canes are difficult to waterproof.

The solution that I came up with, was to use 2.45m lengths of 21mm pvc conduit obtained from the local d.i.y. centre for less than £2 for a three metre length. Then I fitted a bamboo cane down the middle to provide extra strength (**Fig. 5**).

● **Fig. 3: Shown here (on a picnic table) are the four metal bracers that form part of the spider (see text).**

Obviously , you have to select as straight a bamboo cane as you can find. You should also purchase them longer than you require and cut them to length. This is so that you get a decent diameter at the top end of the spreader.

It will usually be necessary to slightly sand down the 'knuckles' of each cane to get them to fit snugly inside the tubing. This must be done with care, as excessive sanding will weaken the cane. An additional 300m length of 25mm pvc conduit should be bonded to the end of the 21mm conduit that has the thicker of the bamboo cane using plumber's pvc solvent cement to provide additional strength. Seal both ends of the spreaders using silicon sealant to prevent water getting in. The spreaders are fitted to the arms using two 35mm hose clips as shown **Fig. 6**.

Assemble the antenna as a conventional quad antennas at first without adding the traps or the linear loading wires. Make temporary attachments for the wires on the spreaders using insulating tape. Both of the driven elements are fed from the same point via a 'quarter-wave' matching stub constructed from 3.5m RG59 (75Ω coaxial cable). The rest of the feeder is standard 50Ω coaxial cable down to the transceiver.

Trim the length of the loops of the driven elements for the lowest s.w.r. you can achieve. I managed to get 1.1:1 at the middle of the band and 1.3:1 at the band edges on the 21MHz band and 1.5:1 over most of the 28MHz band. A lower s.w.r. on this band could probably be achieved by separately feeding the element via a matching stub for 28MHz, but I preferred to sacrifice this for the convenience of a single feed.

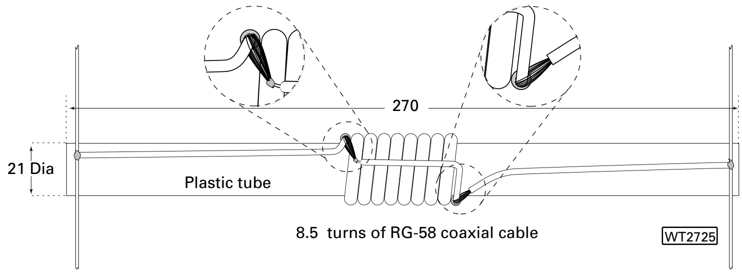
Once you are satisfied with the readings, permanently fix the loops to the spreader by drilling a 1mm hole through the spreader. Then feed a piece of wire through the hole and twist it to the elements. Remember to seal the holes with sealant or waterproof tape to prevent water getting in and damaging the bamboo supports.

Tricky Part

Now comes the potentially tricky part, the reflector. There are two ways to do this, the correct way - or the sane (lazy) way. The correct way requires a reference signal that can be heard by ground wave only and is sufficient strength that it can be nulled-out to some extent by rotating the beam. Then trim the overall length of the reflector bit by bit until the greatest null is

● **Fig. 6 (left): Each spreader is simply clamped to the spider with two 'Jubilee' clips as shown in Fig. 2.**

● **Fig. 7 (below): The linear loading traps are made from eight and a half turns of RG-58 coaxial cable and a short length of 22mm diameter plastic piping.**



achieved. This will inevitably involves re-attaching a short length of wire to the trimmed element that you've cut off. As the only way you know you've reached the bottom of the null is when you've passed it.

With the correct method a null of about 25dB can be achieved in theory however, only over a small bandwidth either side of frequency you set it up on. This null flattens to more modest values away from this frequency. The correct method as described, is only really practical if you can reach the bottom of the reflector loops while in its its operating position.

If however, you have a mast or support that's too high to do the work safely, then you'll end up with muscles like 'He Man' by repeatedly winding the mast up and down. You'll probably have a nervous twitch to boot too!

Alternatively you can go for the lazy (or sane) way as I did, by measuring the final length of the driven elements and adding 3% to the length for the reflector. This will give you an acceptable performance and is liable to be kinder to your sanity.

The final lengths in my version were 13.75 and 14.165m for the 21MHz driven and reflector elements respectively and 10.450 and 10.765m for the 28MHz elements. However, the final value on your antenna will be dependant the wire type as previously indicated.

Once you're happy with the s.w.r. on both of these bands and perhaps worked a little DX on these bands, it's time to move on to 14MHz. You will need to construct four coaxial traps, these follow a similar construction to my inverted L antenna previously published in *Practical Wireless* and are constructed from eight and half turns of RG58 wound on a 270mm length of 21mm diameter pvc conduit as shown in **Fig. 7** and **Fig. 8**.

Important note: It is important to follow the construction exactly as shown as variations will affect the resonant frequency, which may be checked by placing a grid dip oscillator (g.d.o.) near the trap and checking for a dip around 20.2MHz. Check it is the correct frequency by finding the g.d.o.' signal as a carrier on your radio, as g.d.o. scales are not always accurate.

If the trap's resonance isn't near to 20.2MHz, try altering the angle that the interconnecting wire crosses the trap or opening or closing the gap between turns. Once you have determined that each of the four traps is resonant at the correct frequency, secure it in place with pvc tape and then cover it completely with 'Denso' or other waterproof tape.

Mid-Points

Next you should determine the mid-points on the vertical sides of the 21MHz elements on both driven and reflector elements and solder one end of each of the four traps to the element as shown in Fig. 1. Then run a monofilament nylon line parallel to the sides of each elements offset by 270mm. Then you should solder the mid-point of a 1.65m length of 1mm wire to the other side of each trap and attach it to the monofilament line using insulating tape and small cable ties.

To sort out the 14MHz matching once all four traps have been attached, trim equal amounts 10mm at a time from top and bottom of the two loading wires on the driven elements until the lowest s.w.r. reading is obtained on 14MHz. The final length of the loading wires on my antenna were about 1.54m long and I found s.w.r. readings of about 1.5:1 over most of the band. Once you are happy with the s.w.r. cut the linear loading wires of the reflector to the same length and the antenna is complete.

It's difficult to be definitive about performance figures for any home made antenna, especially as few have us calibrated instruments to prove the figures anyway. I've long come to the conclusion, to paraphrase a old saying about statistics, there are lies, damn lies and antenna gain figures. What I can say, is that on average, there is a two to four S-point improvement on marginal signals, when compared to my inverted L. And to confirm that, I'm working a lot more DX.

The first weekend the antenna was up, I managed a contact with the 3B9C Rodriguez Island DXpedition on 28MHz - first call. The station was on-air on 28MHz and most other bands over the following weeks. Although the antenna isn't designed for 18MHz and 24MHz it will 'accommodate' these bands (to quote one commercial manufacturer) when used with the internal tuning units of most rigs. (Just don't expect the same performance as the bands it was designed for).

● **Fig. 8: After the traps are held in place with tightly wrapped pvc insulating tape, they are ready to have the heavy duty waterproofing Denso tape wrapped around them.**

Through judicious scrounging I managed to build my antenna for less than £30 and it knocks the spots of any previous antenna I've owned. So, if you've got a small garden, understanding neighbours and a hankering for your share of the DX then have a go at building this compact quad! **PW**