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The two-element Pentagon

The Loop, the Delta, the Quad – now KI7VR introduces us to the Pentagon, a five-sided design that combines modest vertical height with good performance.

Quads are fine antennas and, on the higher frequencies, are easy and cheap to build. The problem with quads for 40 and 80m is *size* - they are physically huge, but I have found that by making two design changes and one compromise, a 40m 'loop' antenna can be built without too much heavy engineering.

The compromise is in regard to rotation: *don't try to turn it!* The fixed 'loop' is much simpler to build. Obviously a non–rotating, two-element 'loop' should be aligned for the most important DX direction, but it can also be readily switched 180° by changing the parasitic element from a reflector to a director.

The first design change needed to simplify a big fixed Quad is to hang the loops from one corner – this method needs only a single spreader per loop, which in my case, is a vertical bamboo pole. I will refer to a Quad loop hanging from one corner (**Fig 1(a)**) as a 'Diamond Quad'. TI5KD has constructed a single-element Diamond Quad for 80m on a 110ft (35m) tower. The diagonal corner-to-corner distance of this single-loop Quad is 95ft (30.7m) for resonance at 3.525MHz, hence the need for a high tower! The loop corners are pulled out with nylon cord attached near ground level to open up the loop. The resulting loop antenna beams north into the USA/Europe and also beams south to South America. The same tower carries a two-element 40m Diamond Quad which beams north. The signals from these Quads are very impressive, but major engineering is involved. After coming home from operating at TI5KD's shack in Costa Rica, I badly wanted a two-element 40m Quad, but I had neither the cash nor the stomach for heavy engineering. So I sought a way to reduce the height requirement of the Diamond Quad while retaining the single-spreader construction.

PENTAGON DEVELOPMENT

In free space, the ideal loop antenna comprises a circular conductor with a circumference equal to one wavelength [1], or multiples thereof. Circular loops are indeed used on the VHF bands, but on the HF bands, a circular shape is hard to achieve and loop antennas have tended to become triangular (Delta Loops), or square (Quads).

The conventional square Quad needs support at two high points per loop – normally achieved with long spreader poles mounted at 45° to the horizontal using a special bracket on the boom (lots of torque where the spreader pole attaches to the bracket) – this is difficult to engineer for 40m and 80m. The fixed Diamond Quad is simpler and more robust, with its single vertical spreader per loop – but there is a drawback - the Diamond Quad needs 1.4 times more vertical height than the square Quad. The Delta Loop (**Fig 1(b)**), with its flat base, needs less vertical height than the Diamond Quad; however this 'less open' type of loop may not be as efficient as the square loops. John Devoldere, ON4UN, calls the Delta Loop a "Poor man's Quad" [2].

This article describes a Pentagon Loop, which is more 'open' and requires less height than a Diamond Quad, but still hangs from one corner.

The 40m Diamond Quad (Fig 1(a)) has sides 10.87m long and a total circumference of 43.5m. When suspended from a corner, it occupies a vertical height of 15.4m. The corresponding Delta Loop (Fig 1(b)) has sides 14.5m long and a height of 12.6m. The Pentagon Loop (**Fig 1(c)**) has sides 8.7m long and a height of 13.4m. The Pentagon requires only 87% of the vertical height needed by the Diamond Quad shown in (a).

The Pentagon Loop requires but a single vertical support at the apex. The two upper corners are pulled out

FIG 1 © RADCOM 125

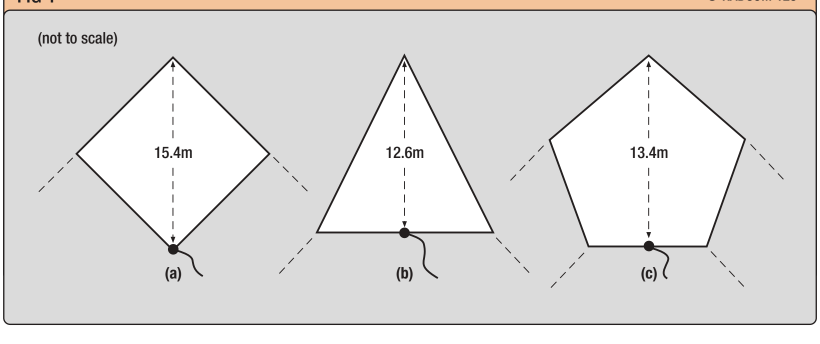
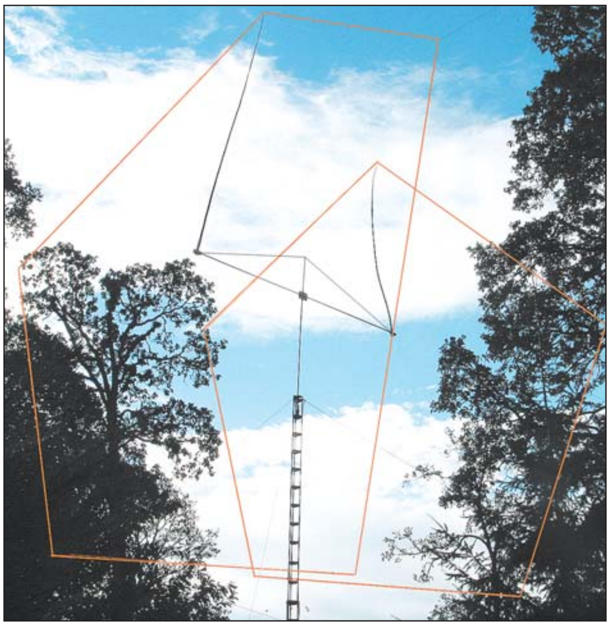


Fig 1
A comparison of three types of 'loop' antenna.

for 40m



The two-element Pentagon for 40m at KI7VR. The wires have been re-touched to make them visible.

with nylon cords to open up the loop.

The bottom is made flat, as with a Delta loop, to minimise the vertical height requirement. It is apparent that the Pentagon Loop is more 'open' than either a triangular or square loop and thus might be expected to radiate and receive somewhat better. A Pentagon has a 10% greater capture area than a square antenna made with the same wire. Tensioning the cords at the lower corners raises the bottom wire a few feet. I am not sure whether the bottom ropes are really necessary – without them, the wire droops in a catenary curve - although the wire hangs closer to the ground, the loop opens up even more.

MY INSTALLATION FOR 40m

An old 30ft crank-up tower was given to me by a friend: I constructed the tower base on the edge of my property where the ground drops sharply to the south. I used a 10ft stub mast made of steel fence railing (1.375in diameter) – cheap, but maybe too flimsy (we'll see). To the stub mast (8ft above tower top), I attached a 20ft boom made of two bits of the same fence railing, the ends of the boom being pulled up to a short centre support pole using Dacron cord, thus preventing sag and strengthening the assembly, a technique used in the past with aircraft wings. Each end of the boom carries a vertical piece of 3in OD aluminium tube (18in long) into which a varnished bamboo pole (homegrown, 20ft long) [3] is bolted. The height at the top of the bamboo is 58ft. The antenna wire (copper-clad steel, multi-strand 14-gauge) is attached to the top of each bamboo pole. A small loop is soldered into each wire at the four remaining corners and Dacron cord attached to each corner point.

How you pull out those top corners depends on your property. If you have lots of space (eg a field) then you can extend the Dacron cords far out until they approach ground level and then attach them to ground stakes. On my half-acre lot, I had to climb nearby trees and put my Dacron cords through smooth plastic rings fixed to convenient upper branches.

After final adjustment of the cords, the bottom wire hangs 19ft above the ground. I had calculated 17.5ft, so I guess it means I haven't quite got my tree branches in the right spots and I don't have perfect pentagons, but I will leave the trees where they are for now. By loosening the ropes, it is possible to drop the bottoms of the loops low enough so that, using stepladders, the coax connection can be modified, or the length of the parasitic element changed.

DIMENSIONS OF THE 40m PENTAGON

Driven element design resonance: 7050kHz.
Side lengths: five equal sides of 8.7m.
Total length: 43.5m.
Reflector length: 103.5% of driven element - four sides of 8.7m, bottom side: 10.2m.
Total length: 45.0m.

Note 1: the resonance shifts a bit with soil moisture content; I needed to shorten the loops as the soil dried out during summer.
Note 2: if the parasitic element is to be a *director*, its length needs to be 97% of the driven element, ie 42.2m. I used four sides of 8.7m and a bottom side of 7.4m.

MATCHING

The two-element Pentagon described above has an input impedance of about 100Ω when fed in the centre of the lower side (see [4] for a discussion about feeding loops at other points). For matching, I used a quarter-wave transformer of 23ft of RG-6/U coax (75Ω) attached at the bottom centre of the driven loop. This connects to RG-58/U (50Ω) running to the shack. The VSWR at the shack is 1.2:1 at resonance and I have run 500W on CW into this setup with no problems. RG-8/U would be better than RG-58/U, but I do things on the cheap!

COST

My total cost was $214 – of which $75 was for concrete mix; steel tube for boom and stub, $21; three heavy-gauge aluminium boom-to-mast coupling plates, $56; Dacron cord and antenna wire, $62. The tower, bamboo and coax were already available.

PERFORMANCE

You may wonder about an antenna that is so close to the ground on 40m. Well, I have a secret - the ground at my QTH falls away steeply to the south, so steeply that I am practically living on a cliff edge. With the antenna pointed at ZL, the boom has an effective height at the boom of 175ft. With 400W into the antenna on 7002kHz, the reports from ZL and VK are that "it sounds like a local" when the band was open (summer 2003). Received signals are up by about two S-points over a dipole and the noise is the same or lower. This antenna gives me good 'ears'. Long-path results to Europe have been excellent with the antenna pointed at New Zealand - eg 599 from OH4RH in October 2003.

Not everyone has a QTH like mine, but the Pentagon Loop is a way to get a low band 'quad' in the air for a reasonable price with a rather small tower. If you can manage to place said tower on a hill or a cliff - so much the better! ♦

REFERENCES

[1] *Low Band DXing*, by J Devoldere, ON4UN, ARRL 1999, p10-1.
[2] *Low Band DXing*, by J Devoldere, ON4UN, ARRL 1999, p10-5.
[3] MFJ Enterprises Inc produces a 33ft fibreglass telescoping mast (MFJ-1910) which, in lieu of bamboo, would probably do the trick. Available in the UK from Waters & Stanton PLC.
[4] *Low Band DXing*, by J Devoldere, ON4UN, ARRL 1999, p10-4.