Antenna Workshop

LOW-DOWN ON LOOPS

Full-wave loop antennas offer several advantages over other types of antennas, says John Heys G3BDQ, as he tells you all you need to know about them.

The 1930s saw a dramatic rise in short wave broadcasting and new stations were appearing every few weeks. Not to be left out, Ecuador built a powerful transmitting station near Quito, its capital city. Situated on the Equator at an altitude of about 3600m, the rarified atmosphere and the station's high power resulted in coronal discharges from the ends of the antenna wires. The station's engineers solved the problem by developing a full-wave loop antenna, and so, the quad antenna was born.

Radio Amateurs were rather slow to pick up on this new antenna design and it was not until the 1940s that **Clarence C. Moore W9LZX** experimented with, then described the full-wave quad (square) antenna. It was soon realised that the full-wave loop could be arranged not only as a square or a diamond so, other shapes of full-wave loops appeared in antenna books.

Characteristics & Parameters

Firstly, let's have a look at some loop characteristics and parameters. The full-wave loop antenna 'family' have twice the conductor length of a half-wave dipole so some gain should be expected. Because the conductor is bent around the actual gain is not the equivalent of a pair of discrete in-phase half-wave dipoles. For a circular loop the gain will be about 2dBd (referenced to a dipole). This represents a power gain of around 1.6 times which would give an e.r.p. of 160W when a 100W output transmitter was used.

The gain (in dBd) when using a full-wave loop antenna is directly related to the area enclosed by the loop. A circular loop encloses a greater area than any other configuration which by the way, is why primitive people build their houses with circular walls. They then have the greatest floor area for the least expenditure and effort.

Four different full-wave loop arrangements are shown in **Fig. 1**. A square (or when tilted a diamond) loop has slightly less enclosed area than a circular loop. A Delta (triangular) loop has less again. The least enclosed area is when the loop is an oblong (letterbox shape). If the flattening continues we end up with a folded dipole, an antenna with the radiation characteristics of a conventional dipole, showing no gain at all.

All the full-wave loops radiate in two directions and the quad loop's gain is about 1.8dBd. A delta loop's gain will be only 1dB or less, giving its best gain figure when formed into an equilateral triangle. The feed-points marked 'F' in Fig. 1 are positioned for horizontal polarisation for the radiation from the two vertical legs of the quad and the sloping sides of the delta have anti-phase antenna currents which largely cancel out.

Vertical polarisation

If vertical polarisation is required, the feed-points should be moved from the base of the loop antenna, to halfway up one of the vertical sides of the antenna. With a Delta antenna, the feed-point should be moved to one of the lower corners. The impedances at the points 'F' are also related to the enclosed areas of the loops. A circular loop has a feed impedance under 100Ω, rising, in the squared form, to lie between 100-120Ω.

With the equilateral delta, the feed-point impedance lies between 75-100Ω. When in a narrow or flattened form loop antennas' feed impedances rises rapidly as the flattening increases until the antenna becomes a folded dipole having a feed impedance of almost 300Ω.

The loop's maximum radiation is in two directions at right angles to the plane of the loop (looking through it). The side, or end-on radiation is minimal. It is the 'end affect' of insulators, etc., which determines a wire's resonant length which will be less than a true half or other multiple of a wavelength.

Closed loops, like all coiled wires must, however, be lengthened to maintain resonance. So, full-wave loops should be cut to a length of 306/F(MHz) rather than the more usual values used for straight dipoles.

The points marked 'V' in Fig. 1 are the high voltage and high

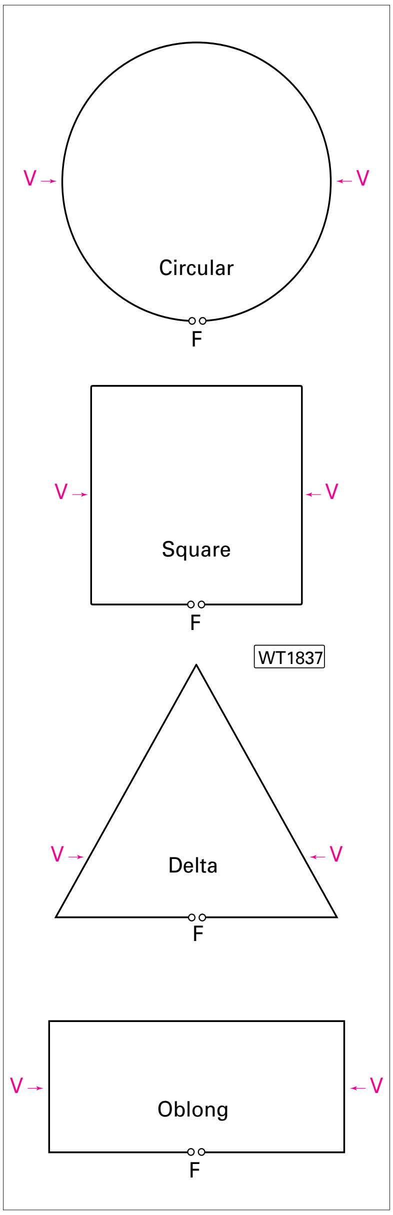

Fig. 1: Four figures having equal perimeters shown in descending order of the enclosed area. Points 'F' are the feed-points for horizontal loop polarisation and Points 'V' are the points of highest voltage and impedance.

impedance positions along the loops. Being closed loops these values are considerably lower than those found at the ends of resonant single wires. This is the factor that proved so useful in Quito. Full-wave loops must be positioned vertically, for when used parallel to the ground, the ground reflection makes almost all the radiation go skywards.

A Disaster

High angle radiation can sometimes be fine for short haul work on the 3.5 and 7MHz bands, but would be a disaster if long distance communication is your aim. Large multi-wavelength loops can however be used in the horizontal plane and they can be effective for long distance working.

Full-wave loops are little influenced by nearby trees or buildings and their lower points can be a λ/4 or less above ground. They can even give good results when made from insulated wire and are actually positioned within trees.

The turning radius of a quad loop antenna is half of that of a half-wave dipole and so, it can be erected in quite small gardens. A loop antenna installed indoors in a roof space will be less affected by the metal tanks, pipes and wires than a conventional open ended wire antenna.

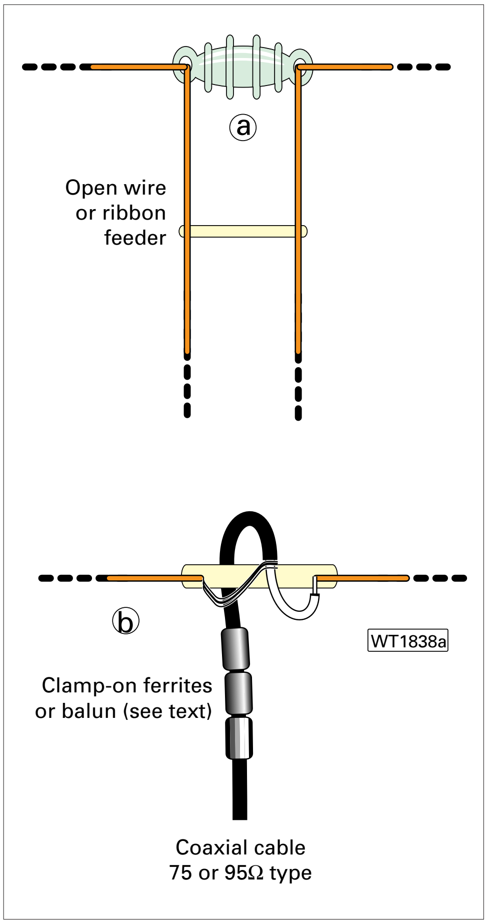

Fig. 2: Three ways to feed a full-wave loop antenna. Open wire feeder or ladder line is the most versatile and will allow operation on the higher harmonic frequencies. See text for details.

First Consideration

The first consideration when thinking about using a quad or delta loop is the question "will it fit into my available space"? Fortunately, a full-wave loop will still be effective even when it is close to the ground. When its lower wire is half-wave above ground the horizontal radiation pattern of the loop will be about four degrees lower than that of a dipole at the same height.

At just λ/8 in height, which is only 2.5m (8ft), when the antenna is cut for the 28MHz band, its horizontal radiation angle will be as much as 10° lower than that of a dipole at the same height. When height is a problem, an horizontally polarised loop may be slanted at up to 45° from the vertical with little ill effect.

A quad loop antenna needs two upper tie points and its corners will all be fairly low impedance points where the insulation is not critical and where just nylon cord without insulators may be used. A delta loop can be positioned with its apex help up by a single nylon cord. The apex impedance is quite low. If the delta is inverted two upper supports are needed and again the impedance at the end points is not high.

Feeding the loop correctly may be done in one of several ways, as shown in **Fig. 2**. A tuned 'ladder' feedline made with open wires or lengths of 300 or 450Ω ribbon feeder is the most versatile feed method. However, this means that a balanced a.t.u. such as a 'Z Match' is needed.

Sometimes the eminently suitable (but now rather elderly) KW Eezimatch balanced tuners may be found at rallies and junk sales. Loop antennas may be fed directly with coaxial cable, preferably by using RG-62AU, with its 95Ω impedance (stocked by **W. H. Westlake** of Holsworthy, Devon).

A good quality 75Ω coaxial cable may also be used, though it will have to be matched to the transceiver. Many modern rigs incorporate an auto-tuner for this purpose. If a coaxial feeder is used to connect to a balanced antenna, a current balun is required to prevent r.f. currents running along the outside braid of the coaxial cable.

An easy and very effective way to make a current balun is to use clamp-on ferrites which are now available. If the cost is more important, then some of the coaxial cable itself may be wound into a four or five turn coil (about 250mm diameter) close to the antenna feed-point.

Traditional Match

The traditional way to match a 50Ω impedance feeder to higher antenna feed-point impedance, is to use a quarter wave matching section **Fig. 3**. This critical length of 75Ω coaxial cable can be determined by multiplying the free space quarter wavelength by the velocity factor of the coaxial cable used. The velocity factor for most cables is around 0.66, but some cables have different factors. The 50Ω coaxial cable need not have any special length.

Full-wave loops fire in two directions so a pair of loops positioned at right angles to each other could give world-wide coverage. The inherent and rather low *Q* of full-wave loops results in a wider bandwidth than that of half-wave dipoles.

When fed from tuned line, a full-wave loop can also be induced to work on its harmonic frequencies, though it will not have the same radiation characteristics of its full-wave use, nevertheless it's still a useful antenna. You cannot use loops on their harmonic frequencies when they are fed with coax, as was discovered by my local club on one Field Day.

Full-wave loop antennas for the v.h.f. bands can be fabricated from tubing or thick copper wire and may be self supporting. Under these circumstances, circular loops may be used to get the full 2dB gain and a 95Ω feed impedance. Additional parasitic elements (loops), to make a beam can bring the feed impedance of the driven loop down to 50Ω. One full-wave loop for 144MHz was made from strips of aluminium kitchen foil, glued to a sheet of rigid plastic material.

Full-wave loops are indeed versatile! They make useful antennas for the amateur bands.

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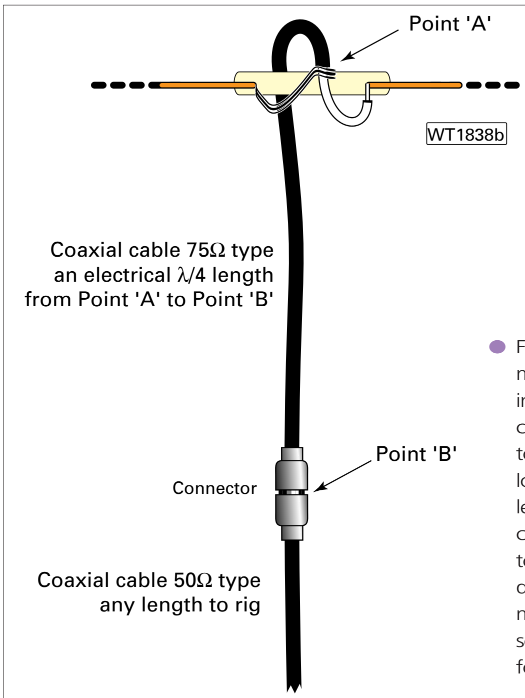

Fig. 3: How to match 50Ω impedance coaxial feeder to a full-wave loop using a length of 75Ω cable that is cut to work as a quarter-wave matching section. See text for details.