Antenna Workshop

Stefan Niewiadomski shows you how to build a balun-fed lightweight antenna for the 14MHz Amateur band. This antenna has been designed for receiving or low(ish) power transmissions and so should appeal to newly licenced M3s.

A wire dipole antenna is usually the first frequency-specific antenna built by many newcomers to the hobby. But sometimes there is confusion on the best way to connect the antenna dipole elements to the coaxial cable feeder cable at the centre of the antenna. This article describes the construction of a 14MHz dipole antenna, designed to use lightweight coaxial cable, solving the issue of matching the dipole to its coaxial cable feeder, and easing the weather-proofing task.

The classic arrangement of a dipole is shown in **Fig. 1** where one end of the antenna is supported by the house and the other end is supported by a pole, maybe with a pulley at the top to make raising and lowering the antenna easy. The antenna itself is isolated from the support ropes by insulators, either 'egg or 'dogbone' in shape.

One drawback of the dipole can immediately be seen: because it has to be fed in the middle, the antenna wire elements themselves have to carry the weight of the insulator in the middle of the dipole and also the weight of the feeder cable.

Arguably the neatest and most compact form of feeder is coaxial cable, but because it has an outer sheath and an inner conductor it's inherently unbalanced, although the dipole elements are balanced in nature. Connecting the coaxial cable feeder directly to the dipole radiating sections can cause the feeder to radiate power (in the transmit case) and pick-up unwanted signals (in the receive case).

Lightweight Coaxial

The lowest-weight coaxial cable easily available is RG-174 which is commonly used for screened r.f. wiring inside radio equipment. This cable is only just over 2mm in diameter and therefore is very lightweight and flexible. Experimental work[‡1] has shown the attenuation of this coaxial cable to be only about 3.5dB per 30m (100ft) at 15MHz, compared with 2dB for commonly-used RG-58.

In the set-up for my 14MHz dipole, I used only about 10m of feeder so, the losses in the RG-174 would be negligible. From this data it seems completely unnecessary to use heavy RG-58 for receive and low(ish) power transmit (see below) applications. RG-174 is marginally more expensive than RG-58, but in my view this is far outweighed by its advantages.

I do not intend to go into the theory of balanced-to-unbalanced transformers (baluns) here, this being covered in much reference material. A typical balun is shown in **Fig. 2**, illustrating the construction as a trifiliar winding on an FT50-61 ferrite toroid. Note the phasing of the windings, which are wound side-by-side on the toroid. The windings transform a balanced input applied between pins 1 and 5 to an unbalanced (ie one side is grounded) output between pins 2 and 6, while maintaining a 1:1 impedance ratio over a wide frequency range. The terms input and output in this context refer to a receive signal direction: a balun is bidirectional and so the balance-to-unbalanced action is effectively symmetrical.

Calculation Of Size

There are many references to the calculation of the sizes of various antennas. The overall length of a dipole antenna, when corrected for end-effects is given by:

L = 143/f

Where: L is the overall length in metres and f is the mid-band frequency in MHz. Assuming a centre frequency of 14.2MHz, then 10.07m is the overall length for that band. Each run being almost half of that distance. In my design the centre ends of the elements are separated by 25mm on the p.c.b., and so the length of each element is (10070 – 25) / 2 = 5023mm. Other bands can be accommodated with this design, simply re-calculate the overall length and hence the length of each element.

Because the balun transformer T1 contains only nine turns of wire, it's easy to construct even though it is trifilliar wound, see Fig. 2. Cut three 200mm lengths of 0.4mm (actual size is not too critical) enameled copper wire and wind the three wires side-by-side on the toroid, being careful not to cross the wires as you pass the wire though the core. This takes a little time, but is not too difficult to achieve. When the nine turns have been wound, cut the ends to about 25mm and finally cut to length and scrape off the insulation when mounting on the printed circuit board (p.c.b.) (see below).

The balun is mounted on a small p.c.b., **Fig. 3**, which is supported by the dipole element wires, and separates the centre ends of the dipole elements. Terminal pins were used on the prototype to which the toroid wires and feeder coaxial cable were soldered, rather than trying to pass these through the p.c.b. and soldering to the track side. I find this to be an quicker way of making these connections, and easier to ensure good soldered joints.

The p.c.b. also forms the insulation medium between the elements and is strong enough to take the longitudinal strain in the element wires. The feeder coaxial cable also terminates on the p.c.b. and the coaxial cable is secured to the p.c.b. by small loops of insulated wire to relieve the strain of the vertical section of coaxial cable hanging down from the centre of the dipole. Because miniature RG-174 is used in this design the

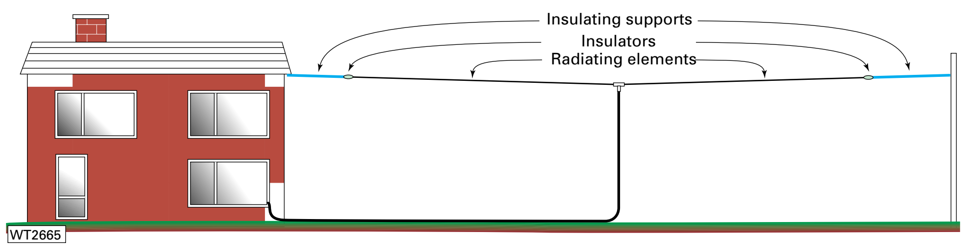

Fig. 1: A typical λ/2 dipole fed with coaxial cable feeder.

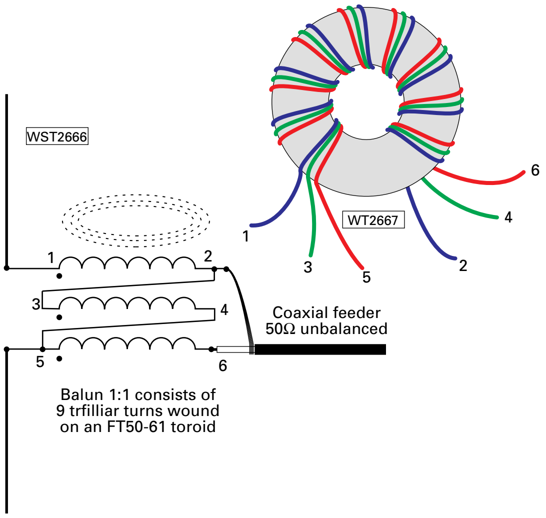

Fig. 2: The electrical and physical diagram of the toroidal transformer. See text for more details.

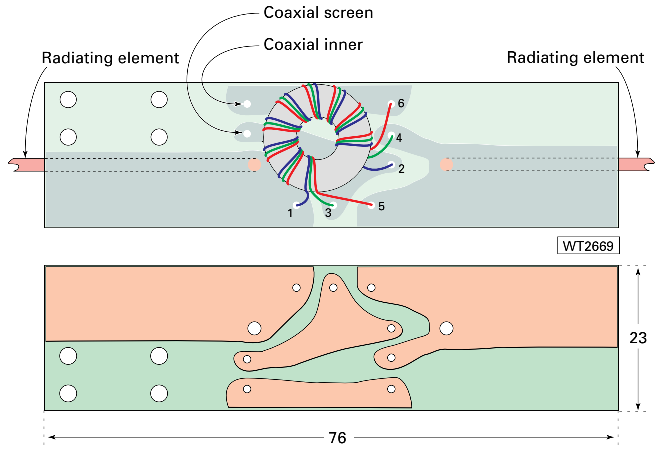

Fig. 3: The p.c.b. and layout for the dipole centre. See text for more details.

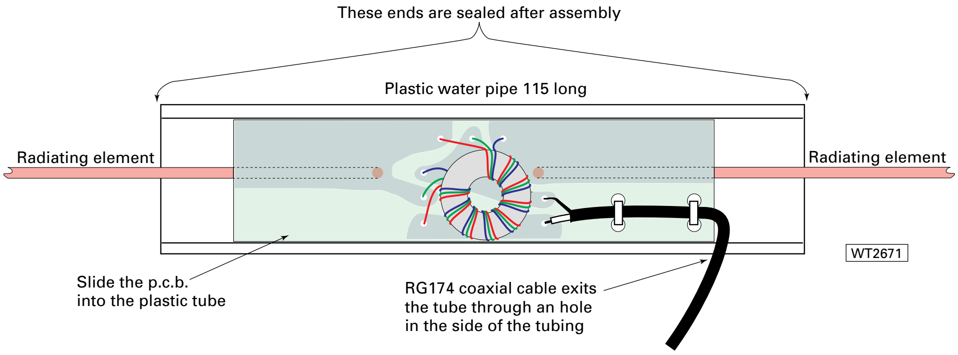

Fig. 4: And this is how the dipole centre is fitted into the section of plastic plumbing pipe. When mounted and secure, the ends are sealed against moisture ingress.

weight of feeder supported is minimal, contrasting with RG-58-type feeder which is much heavier.

When cutting the dipole elements to length, first of all, connect the wire to the insulator by passing its end through the insulator and then tightly twisting about 70mm of the wire around itself. Then measure the length needed (5023mm for the 14MHz version) and put a sharp right-angled bend in the wire and leave about 10mm extra beyond the right angle, before cutting it. It's a good idea to measure the wire carefully a couple of times before making any cuts to save possible mistakes and wastage.

The right-angled ends of the elements are pushed through the 1.5mm mounting holes in the p.c.b. from the track side and soldered to the copper. This arrangement transfers the strain in the elements into the p.c.b. insulation material itself.

Not Stretching

I used 1.5mm (16ws.w.g.) hard drawn copper wire, that has the advantage of not stretching over time, for the elements. Normal copper wire stretches over time causing the antenna to sag and change its centre frequency because of the increase in length of its elements. The recommended wire may be replaced if smaller diameter hard drawn wire can be found. By this means the antenna will become lighter overall and make it less visually obtrusive.

The p.c.b. with the balun mounted is illustrated in and the dipole elements and feeder coaxial cable attached, ready to be slid into the 115mm length of 22mm outside diameter polythene tube, **Fig. 4**. (the critical diameter is actually the inside one, which has to allow the assembled p.c.b. to slide into it). The tube needs to be drilled with a 2.5mm hole to allow the coaxial cable to exit the tube.

Don't forget to slide the tube onto one of the wire elements **before** attaching the insulator to the element wire. I didn't and in my case I had to take the insulator off again!

After the p.c.b. and tube arrangement have been assembled, it's a good idea to cut the coaxial cable feeder to length, solder an appropriate plug to suit the antenna socket on your receiver, and temporarily erect the antenna and test it. Compared to an long-wire antenna the dipole should produce signals at least a couple of S-points stronger. If the system works well, then take it down, weatherproof the assembly by sealing the ends of the tube and the coaxial cable entry point with silicone (bathroom) sealant and re-erect the antenna.

Excellent Results

The antenna has been in use for several months and at my station has produced excellent results, band conditions permitting. Signals from the east and west coast of the USA, Canada, Oceania, Africa and of course from all over Europe have been heard. It also seems to work well on 7MHz (40m).

As previously mentioned, this design was intended for receive use only, but is also suitable for low power transmissions up to about 10W. I've seen an Internet-discussion of the power handling capability of miniature RG-174 cable‡2, and 100W seems to be the accepted figure. I think I'd limit the power to something less than this, maybe 20W, depending on the length of feeder used.

The FT50-61 toroid should be capable of handling 10W, but if more power is used, try an FT68-51 core, though still with the same number of turns. It may be necessary to use a larger diameter tube to accommodate the bigger toroid.

There you have it, a simple, but effective balun-fed dipole antenna for the 14MHz band. **PW**

Shopping List

T1 balun wound on FT50-61 toroid.
0.4 mm enamelled copper wire for T1.
1.5mm hard-drawn copper wire for dipole elements.
a short (115mm) length of 22mm outside diameter polythene tube (plumbing pipe), silicone sealer, printed circuit board, terminal pins, RG-174 miniature screened cable, plug to suit the rig, two-off 'egg' or 'dogbone' insulators, nylon support rope.

The toroid, copper wire, RG-174 and insulators may all be obtained from **Sycom** (tel 01372 372587, E-mail: **robin@sycomcomp.co.uk**, or see **www.sycomcomp.co.uk**)

References (‡)

1) Notes on using RG-174 coaxial cable at medium and lower h.f. frequencies: **www.dxing.info/equipment/rg_174_coax_bryant.dx**

2) [Amps] RG-174 power handling capacity: **http://lists.contesting.com/archives/html/Amps/2002-04/msg00156.html**