**Mike Jones'**

# antenna workshop

Stuck for space but keen on trying 14MHz for DX? Mike Jones G3UED could have the solution for you!

## An Effective 14MHz Band Loft Antenna

Amateur Radio dipole antennas are generally a half wavelength (λ/2) long at the frequency of operation. They are usually made of copper wire and are centre fed. When at resonance, which occurs when the length of a practical antenna is about 95% of the free-space perfect half-wavelength value, the feed-point exhibits zero (0Ω) reactance (the inductive and capacitive terms cancel) and so it presents a purely resistive load to the feed cable.

The value of this resistance is of the order of 73Ω consisting mainly of the 'Radiation Resistance' plus resistance responsible for inevitable losses. Consequently, a low voltage standing wave ratio (v.s.w.r.) can be achieved when connected to a transceiver with low impedance coaxial cable.


### Radiation & Loss Resistance

Radiation resistance is an imaginary resistance representing the radiation capabilities of the antenna and is dependent upon its geometry. Loss resistance is the part which wastes energy as heat generation in the wire, connectors and joints. It also includes losses due to coupling into nearby objects.

So, the higher the radiation resistance, the more of the supplied power is radiated and the more efficient the antenna. Conversely, the higher the loss resistance, the more energy is wasted as heat and the efficiency reduces.

Modern transceivers usually have a 50Ω coaxial (unbalanced) antenna socket. Although 50Ω coaxial cable (I used RG213 cable), presents a small mismatch at the antenna, only a small amount of energy is reflected resulting in an acceptably low v.s.w.r.

The formula used to determine the overall resonant length (L) of such a dipole is:

L= 468/F(MHz) where L is in feet
or
L=143/F(MHz) where L is in metres

The lengths given by the above formulae are the total end-to-end length of a practical horizontal dipole installed in an ideal situation. Each half of the dipole will therefore be one half of the lengths calculated.

For example, using the above formulae for my 14.2MHz (design frequency) antenna, the required length is 10.07m (33ft) for each half.

Sloping the antenna elements to fit into restricted sites is acceptable – the overall wire length to maintain resonance reduces slightly from those calculated above. But, of more concern, is that the radiation resistance and therefore efficiency fall rapidly as the apex angle is reduced (i.e. The overall end-to-end length is reduced). An angle of greater than 90° should be the aim when installing this way.

The final length, for a given installation, is usually found by experiment. Nevertheless, the formulae I've mentioned provides a good starting point.

Proximity to things such as roofs, cabling, metallic objects etc., will further reduce the efficiency due to energy being coupled and dissipated in these nearby objects. So, practical installation considerations all conspire to reduce the radiation resistance and therefore efficiency by reducing the wire length for resonance and the linear length of the antenna and increasing losses due to coupling.

### Indoor Or Outdoor?

The ideal installation for a dipole would be erected at a full half wavelength high and clear of all conductive structures, etc. Although this would surpass the effectiveness of an indoor dipole, the latter is often the only one available for many of us. However, despite its lower efficiency, the indoor option should not be discounted when a loft space is available because it can produce surprisingly good results.

*Fig. 1: Three lengths of enamelled copper wire are twisted together to form one composite 'wire' to form the balun.*

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**Note:** When using high power, high radio frequency (r.f.) voltages can appear at the dipole ends (the current maximum is at the centre). Consequently, to eliminate fire risks, low power and frequent inspection is recommended to ensure r.f. sparking at these points does not occur.

Unfortunately, loft installation for antennas is often hampered by timber struts and trusses, apart from the usual stored household items! My loft space is a convenient storage space for all-manner of useful items. I say 'useful', but my wife disagrees, of course!

In my case, living in a house of modern construction, the loft is only some 6.4m wide with a 7.9m long ridge running east-west. The roof construction is of the timber trussed type, common in modern houses, with trusses at some 600mm apart reducing the usability of the floor space making it difficult to move about the area.

Where sufficient free space is available, the dipole may be installed by fixing the ends, either by securing them to suitable parts of the roof structure, or by using string to extend the wire in order to reach support points. I used small metal eyelets screwed into timber struts. An additional length of wire will be required to account for knots or loops formed at the wire-ends.

It's also important to ensure the wire elements of the antenna are installed **as far away as possible** from house wiring, pipes, tanks and stored metallic items. However, although the phrase 'as far away as possible' is often used in this context – readers will probably ask the obvious question, "What does this mean in practice?

To answer, I'd have to reply, "Well, in my case, the cabling in my loft runs at right angles to my dipole (which helps to reduce undesirable coupling) with the nearest cabling being some 2m away. Many would say this is far too close, but I have experienced no interference to household devices. I'm also fortunate not to have any pipes or tanks within my loft, which is an advantage!"

## Initial Design Considerations

Although it was nearly of sufficient length to install my 20m dipole along the ridge of the loft, I decided not to do this because of electrical wiring running at high level – feeding loft lighting. Additionally, my shack is in a downstairs room with an outside wall at the gable-end of the house and this makes a vertical feeder cable drop in this position more convenient than feeding it vertically down in the centre of the house.

To meet these requirements the dipole centre needed to be at the gable wall, employing sloping elements. **Note:** Despite the lower radiation resistance this brings, together with the consequential lower efficiency, sloping elements in the form of an inverted 'V' can have advantages. This is because that a degree of low-angle radiation occurs and therefore brings the potential to make longer distance contacts. (Or so I hoped!).

Loft installation will lower the radiation resistance from the 73Ω in free space due to close proximity to so many items, not least the roof itself and also the ground. Sloping the elements will cause a further reduction.

Furthermore, as the feed-point impedance will now be well below the ideal 50Ω, a mismatch will occur between the feeder cable (assuming 50Ω coaxial cable) and the antenna causing energy to be reflected. However, in practice I've found this mismatch not to be too

*Fig. 2: After winding six turns of the composite 'wire' on the ferrite rod, the individual ends are identified and labelled.*

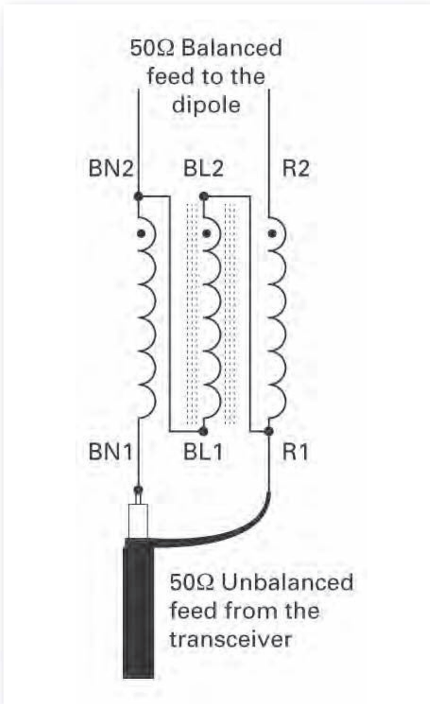


*Fig. 3: The circuit and connections of the balun. Points 'BN1 and BN2 are the start and ends of the strand labelled brown. The notation is similar for the 'blue' and 'red' strands.*

problematic and I achieve a v.s.w.r. of less than 1.5:1 from 14.000 to 14.270 – a very acceptable bandwidth. (My lowest reading is actually 1.15:1 at 14.100MHz).

## Balanced & Unbalanced

A symmetrical horizontal dipole, when centre-fed, presents a balanced termination to the feeder. A coaxial cable, although nicely matched to the output connector of a modern transceiver, presents an unbalanced feed to the antenna. While the impedance match may be acceptable, the unbalanced-to-balanced connection can cause r.f. currents to appear on the coaxial cable screen.

The unwanted r.f. currents can result in undesirable radiation from the feeder cable and interference to household and shack equipment. This stray r.f. can also cause minor r.f. burns to occur in the shack – especially when extraneous metalwork is touched. (The measured and displayed v.s.w.r. may also seen to be erratic).

So, to overcome the undesirable effects, a balanced-to-unbalanced transforming device is used. These are commonly referred to as ‘baluns’.

The Balun I chose for my loft dipole was one described by the late **Les Moxon G6XN** in his book entitled *HF Antennas for All Locations* (published by the RSGB and available from the PW Bookstore). The balun provides a 1:1 impedance ratio and is a broad-band device suitable for 3-30MHz and is simple to construct using easily available parts.

I used three lengths of 22s.w.g. (0.711mm diameter) single strand enamelled wire about 400mm long. The three strands were laid alongside each other and twisted together very tightly using two self-gripping pliers (as seen in **Fig. 1**) Six turns of the resulting composite twisted wire was then wound onto a length of scrap ferrite rod 10mm by 85mm (dimensions are not at all critical) as suggested by G6XN.

The tricky part is then to ensure that each end of each winding is correctly identified and connected. To start the process, first remove the enamelling with a piece of fine sandpaper and tin the ends with solder. I then identified the ends with my multimeter and marked them with small pieces of coloured insulation tape, as shown in **Fig. 2**.

The diagram, **Fig. 3**, is a schematic of the balun. Dots identify the three ends that emerge from the same end of the coil and **it’s imperative** that the connections are made in the manner shown. The terms R1, BL1 and BN1, etc., refer to the coloured tapes I used to identify the wires.

The photograph **Fig. 4,** shows how the ends of each of the three wires are terminated into (15A) connector blocks to enable connection to the dipole and the feeder cable. I then mounted the two connector blocks onto a piece of wood 25 x 100 x 12.5mm as shown in **Fig. 5**.

**Note:** Although I’ve operated my antenna and balun with my rig

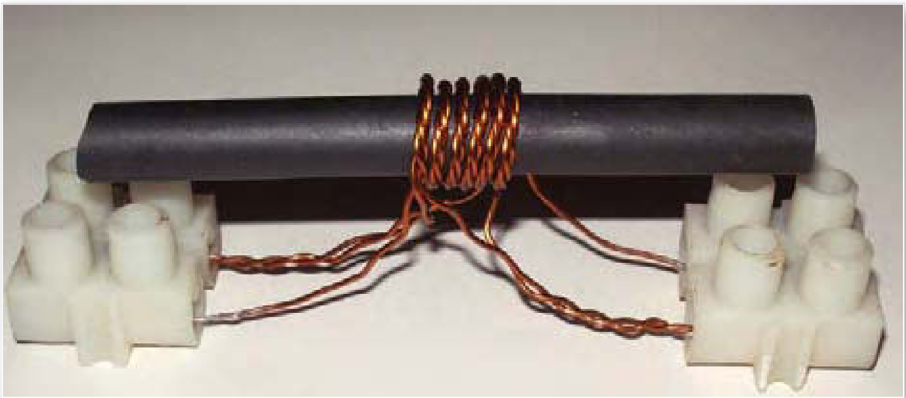

*Fig. 4: After winding the six turns at the centre of an 85mm length of 10mm diameter ferrite rod, the ends are clamped into two connections blocks.*


*Fig. 5: The balun mounted high in the apex of a gable-end wall.*

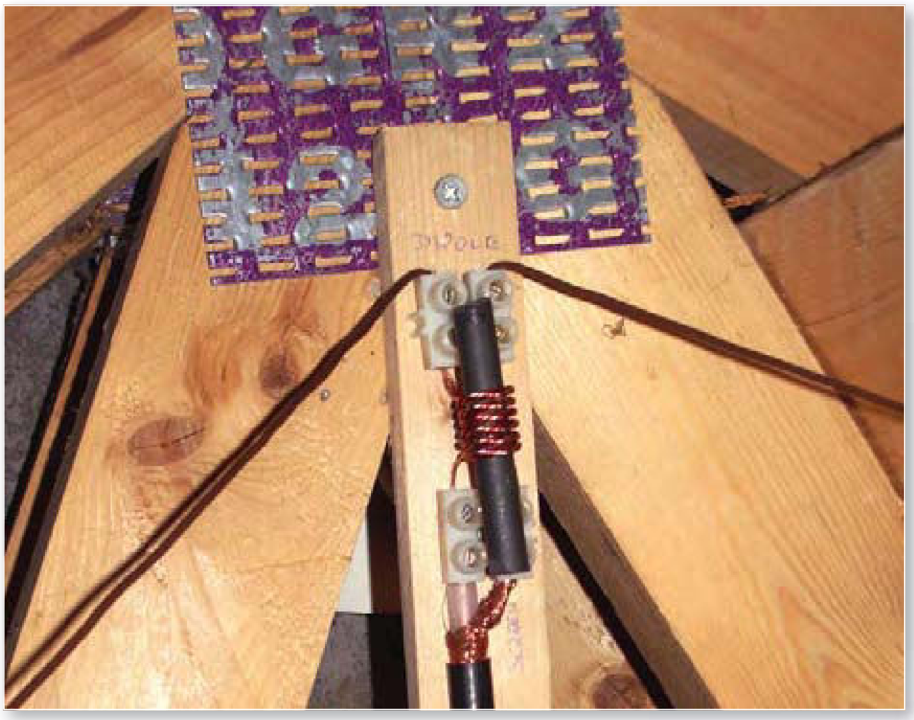

*Fig. 6: The balun shown mounted at the apex of the roof joists. The slotted plate is used to hold the junction of the roof joists together!*

*Fig. 7: Looking up into the apex of the roof, showing the inverted-V formed with the wires. The angle formed will most likely be different in house of different ages, as roof apex-angles have changed.*

*Fig. 8: Looking at the open end held tight with string attached to a roof joist.*

operating at the 100W level, and there has been no temperature rise noted, care should be taken with low power used initially to ensure no heat is produced.

## Installing The Dipole

The pictures **Fig.**s **6** and **7,** show how I installed my dipole and the wire I used was plastic covered multi-stranded equipment wiring of only 1mm diameter (2mm outside diameter), although thicker wire would have been better because it would reduce the loss resistance. The balun, mounted on the piece of wood, forms the centre piece and needs to be positioned as high as possible.

The wire elements of my dipole run away in direction from the outside wall but close to the roof until they meet the loft floor, where I tied them off with string to screw-in eyelets as shown in **Fig. 8**. **Note:** Remember that any wire used to form knots or loops for securing the ends is additional to the dipole length. Any excess should be tied back along the length of the dipole element – where it won't contribute to the radiating length.

Each final element length in my case was 4.8m (15ft 9in). The feeder cable (I used a suitable length of RG213) drops down vertically through the loft floor, through the room below and into my downstairs shack.

The apex angle of my particular installation is somewhat less than 90° and is far from ideal. This is because the radiation resistance of my dipole will be significantly lower than 50Ω – resulting in quite low efficiency.

## Testing & Adjustment

I carried out the testing and adjustment using low power on a clear frequency around 14.2MHz, fed through my v.s.w.r. meter. Starting with the original design lengths of about 5m each side, I shortened each wire by about 50mm each side each time until the lowest v.s.w.r. appeared at 14.2MHz.

**Note:** I've checked and can't detect any stray r.f. in the shack and believe the balun is doing its job.

Despite the low efficiency of my loft installed 14MHz dipole, I've obtained surprisingly good results! I've worked various parts of Europe, North Africa and the Middle East, generally with good reports over the last two years or so when sunspot activity has been at its lowest. Not bad for a simple installation!

The theory and practical considerations described above apply equally to the installation of a dipole for any h.f. band, either indoor or outdoor, and the formulae for calculating the element lengths holds true. And, since the balun described above will cover the range 3-30MHz, it can be used to successfully feed any Amateur band dipole working between 3.5 and 29.7MHz. **Note:** Suitable weather protection for the balun and all the associated connections would be required for outside installation.

My next installation will be dipoles for 18MHz (17m) and 21MHz (15m) and I'm planning to install these with the wire elements connected in parallel with my 14MHz dipole, using the Balun as a common feed for all three.

In theory, because their resonant lengths will be shorter, I should be able to install these with greater apex angles ,which will give better efficiency and (hopefully) I'll achieve good results on those bands too, and I'm planning to share the results I get in a future Antenna Workshop.

Good DX!

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