Antenna Workshop

Stephen Cole G3YOL gets the most out of a small space for Top-Band h.f. operations.

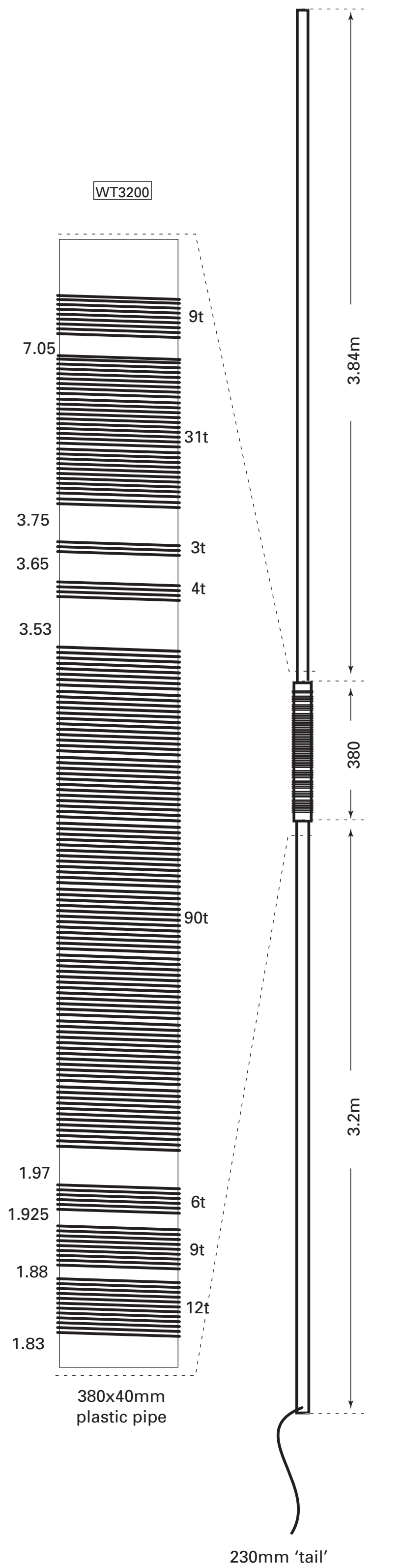

Fig. 1: The overall layout of the radiating element of the three low-band vertical antenna.

A suitable antenna was required for use on 1.8-7MHz at temporary locations, often with limited space. I decided that a ground mounted quarter-wave loaded vertical would best meet the space limitations, fed with coaxial cable against earth. The ability to erect the antenna single-handed was also important!

My previous experience of building 'Top-Band' (1.8MHz) mobile antennas suggested that best radiation occurred with a resonant antenna and a long centre mounted loading coil. The higher the loading coil the greater the length of the section carrying maximum current, which increases radiation, although also increasing the size of the coil needed.

The higher and larger the coil, the more difficult it becomes to erect, so that centre loading is an arbitrary compromise (but seems effective).

Increase Radiation

Making the coil appreciably longer than the diameter seems to increase radiation from the coil when compared to a coil proportioned for minimum loss. However, with a coil tapped for multiple band operation, the coil proportions are better at the higher frequencies where the r.f. wire resistance per unit length is greater due to increased 'skin' effect.

Consideration of coil losses is probably academic since they are likely to be negligible compared to the various ground losses, which usually have to be accepted with this type of antenna. This does assume that a reasonable size of wire is used for the coil, not smaller than, say, 18s.w.g. (1.2mm)

Antenna Construction

While this description for the antenna construction is fairly detailed, the methods used should be modified to suit the materials available and the ideas of the constructor. The materials used to construct my antenna were mostly those that I already had to hand.

The aluminium tube was some old one inch and three quarter inch electrical conduit; this was used for the lower and upper sections respectively. Incidentally, the lengths I had meant that my coil was mounted below centre.

The sections were joined by a length of fibreglass tube with an external diameter that would fit inside the larger aluminium tube (with a little filing) and over the small diameter tube. This was used to carry the coil and to join the two lengths of aluminium tube as well as at the base of the antenna. The coil was wound with 18s.w.g. enamelled copper wire on a fibreglass tube about 40mm diameter.

A length of steel pipe was found (old three quarter inch electrical conduit) over which the bottom fibreglass tube was a good (but free) fit. This was used for the antenna ground post and fitted with a spring clip at a suitable level to support the antenna base tube above ground. (The ground post must be protected when driven to avoid belling of the top if this mounting system is used).

Note: The antenna was often used as it's been shown here, being carried to the site in two sections on a car luggage rack. When I changed to a car without a rack, I had to divide the antenna into four sections so that it would then fit inside the car. The new divisions were joined with carefully shaped hardwood dowels. A carrying container was made from rainwater down-pipe for the earth rods (described later) and the ground post, a good idea as these are usually dirty after use.

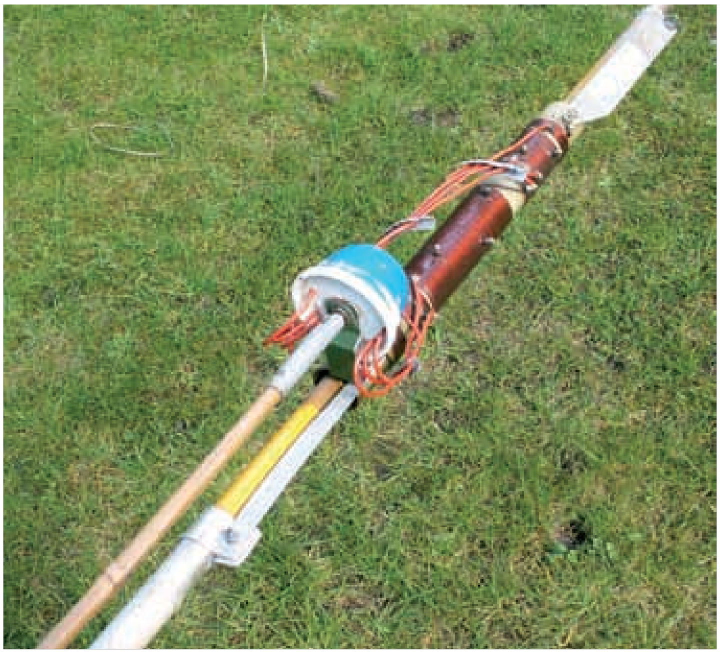

Fig. 3: The mid-antenna mounted band-change switch.

Fig. 2: The base, showing the ground connecting leads. They connect to the screen of the coaxial cable feeder.

The Coil

I didn't know how many turns would be required on the coil so, the antenna was first constructed with a long coil with multiple taps and mounted to one side of the smaller diameter central fibreglass tube. After erecting the antenna the resonant frequency was checked for each tapping - using an accurately calibrated gate dip oscillator (g.d.o.) coupled to a two turn coil plugged into the SO239 socket at the base.

Using a g.d.o. is the only reliable way to check for resonance – don't adjust for lowest standing wave ratio (s.w.r.). The unused part of the coil was shorted by a lead permanently connected at the bottom, which could be securely clipped onto the selected tap position.

I secured the taps by inserting brass screws into the former tube by drilling and tapping. The thread under the screw heads was first filed away to leave a smooth surface, this was then tinned. After inserting the screws the heads were cut off.

The wire's insulation was stripped at the screw, before wrapping it around the screw and soldering it. Care had to be taken to control the wire of the coil while soldering because the heat softened the resin but this set again after cooling. The screws were left long enough to accept a crocodile clip.

The resonance figures were used to make the first adjustments to the coil taps. The coil was found to be much longer than necessary so the former was shortened to 335mm before being mounted coaxially over the centre fibreglass tube.

The centre tube must be long enough to ensure that the aluminium tubes do not reach inside the coil. The coil former was secured to the inner tube by forcing in some (firm) plastic foam a little way at each end and then pouring in some resin.

Coil turns were subject to adjustment at various stages. Care must be taken not to remove too many turns at a time. It's easier to take turns off than put them back! If starting again with the information that I now have, I would wind and adjust the top part of the coil, then the next one down, and so on.

My antenna uses four taps for 1.8MHz, three taps for 3.5MHz and one tap for 7MHz. It might be considered an advantage to increase the number of taps or slightly change the selected resonant frequencies.

Band Switching

It's very inconvenient having to lower the antenna to change taps! This problem was overcome by fitting a rotary ceramic switch adjacent to the coil to change taps (the switch was mounted inside a plastic food container).

A removable bamboo rod set into a calibrated horizontal indicator plate about 1.2m above the ground remotely operates the switch. A hole was then drilled through the shaft of the switch and tapped to accept a steel screw secured tightly without the need for a lock nut. The screw extended out of the shaft only on one side. I then cut the head of the screw off.

A coupling at the top of the bamboo shaft was made from some plastic tubing with a slot on one side to engage with the screw on the switch shaft. **Note**: To be able to install and remove the bamboo with the antenna erected it's necessary to mould the plastic adapter into a bell mouth.

The size of the bell mouth depends mainly on how adept you are at handling a snooker cue! I always remove the bamboo and keep it at the operating location to be sure that nobody can operate the switch during transmission.

A good quality ceramic switch is essential, and even then care must be taken to avoid the risk of burning non-ceramic insulation. After some use the original switch had to be replaced because of burning of the Bakelite rear support of the switch spindle. Part of the replacement support was first filed away to give greater clearance. RF voltage around the coil and switch is very searching.

Earthing Rods

Three earth rods, each about 1.2m long are interconnected with the ground post by clearly visible leads and heavy crocodile clips and to the earth terminal near the SO239 socket. The rods also serve as pickets for the light plastic guys, the top ends of which are tied to a Perspex ring resting onto a clip above the loading coil.

The earthing system should be considered the minimum acceptable and in dry soil will need to be kept well watered during operation. The antenna has been used in dry sand dunes, where quarter-wave radials were used lying on the dry sand and morning contacts to South

America were made on 7MHz.

Radials are very inconvenient to use where the general public have access. If there were room for radials there would be room for a better antenna, such as a dipole, doublet, or G5RV.

I recommend the use of copper clad steel earth rods if they can be obtained. I have had a few of these for many years and they have withstood being driven and removed many times. The expensive but flimsy copper rods offered today would not have stood up to such use. Another alternative is to use galvanised steel rods Finally, here's a health and safety warning! Muscle power and a lump hammer usually give no problem for driving in the earth rods. However, withdrawing them again is a different matter! I always grasp the rod with self-locking grippers and pull while twisting each rod. But remember - try to keep your back straight and use your legs to pull!

For permanent earth installations I have sometimes used 15mm copper pipe after driving a hole with a steel fencing spike. If you find any of the old half-inch copper water pipe this would be even better – it is heavier gauge!

Whichever type of rod or pipe is used remember to space them at least the length of the rod apart. Burying an old hot water tank helped one very successful installation. Watch out for these because the old ones (without factory fitted foam insulation) are becoming quite rare.

Feeding & SWR

The antenna is fed using 50Ω coaxial cable (UR67) and, if necessary for the transmitter, a matching unit (a.t.u.) at the transceiver. Over the whole bands the s.w.r. on 1.8MHz is between 1.5:1 and 4:1; on 3.5MHz between 1.5:1 and 3:1; and on 7MHz between 1.4:1 and 1.7:1. This is no problem for the feeder and almost any a.t.u. should be able to deal with it.

The antenna has been used with 400W input, before fitting the switch. Restricting the power to 100W would be safer. Fitting the switch only marginally altered the resonance frequencies

A quarter-wave antenna physically shortened by means of a loading coil will have a low feed-point impedance, but the best radiation will be achieved by operating it at resonance because this ensures maximum current in the unloaded part of the antenna. However, this may not give the lowest s.w.r.

The antenna did, in fact, show minimum s.w.r. at slightly above its resonant frequency. This can be explained by realising that under those conditions maximum current occurs in the loading coil, thus increasing losses and raising the feed-point impedance.

Material Difficulties

It may be difficult to obtain the same materials as those used for the prototype. Smaller and tapered sizes of aluminium tube should be satisfactory for the upper section. The upper section of my antenna is reinforced at the bottom with a short length of smaller aluminium tube inside to counteract the lighter gauge of the long tube.

For the smaller size fibreglass tube a reinforcing layer of fibreglass and resin could be applied to a plastic tube. After some experience with the antenna, I found that similar reinforcement was necessary for the bottom fibreglass tube I used.

If the antenna is to be erected permanently any exposed resin should be protected from sunlight by painting. A good thick layer of exterior varnish should be built up over the coil to because of u.v. light from the sun.

Two additional top sections were made. One reaching 1030mm above the top of the coil former gave resonance at 14.160MHz, and one 1550mm for 10.120MHz operation - both with the switch set for the 7MHz band.

Capacity Hat

Consideration could be given to top loading by means of a capacity hat. This would allow shortening of the antenna, or, alternatively, reducing the size of the loading coil, or perhaps a combination of both. Reducing the size of the coil would improve efficiency, but maintaining the same length with the addition of a capacity hat would obviously make erection more difficult unless stronger tube is used.

If the number of turns were reduced the coil turns could possibly be spaced, which could reduce coil losses. Also if operation on the 1.8MHz band isn't needed the coil could be appreciably smaller than the one described here.

Fig. 4: The calibrated band-indicator plate with the bamboo stick used to operate the band-switch.

Operational Experience

The bandwidth for an s.w.r. of less than 2:1 is 25kHz on 1.8MHz and 75kHz on 3.5MHz. Better than this cannot be expected for an antenna that is so short in terms of wavelength. Nevertheless, remember that it will be most efficient at resonance, not at the lowest s.w.r.. If an s.w.r. of 1:1 is most important replace the antenna with a dummy load. The s.w.r. will be perfect but you won't make many contacts!

The s.w.r. is less than 1.7:1 over the whole of the 7MHz band. With 7MHz selected it also shows an s.w.r. of less than1.5:1 over the 21MHz band but I am very doubtful that good low angle radiation would result.

This cheap home-constructed antenna has met the original aims well. It has proved itself over the last 15 years at a number of /P locations. It has also been used for many special event stations, sometimes with very unusual mounting arrangements. The use of 'home-brew' equipment is very satisfying.

●