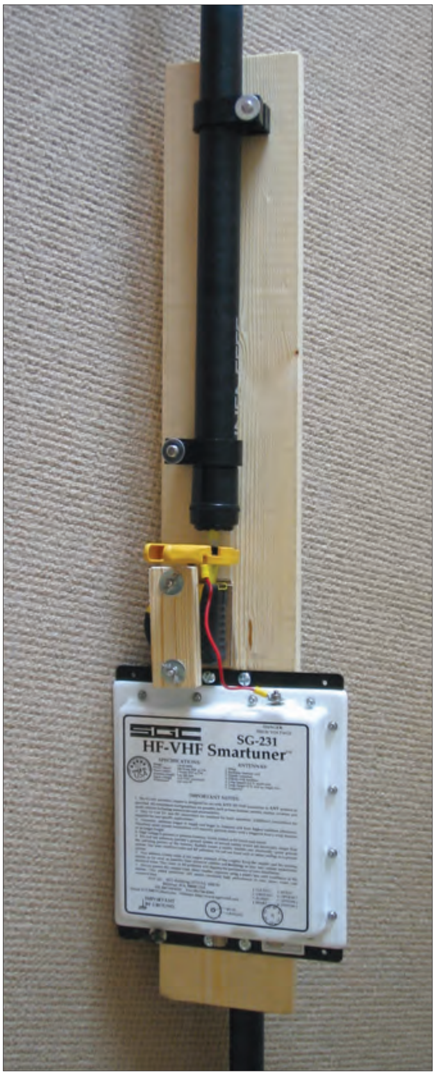
Antenna Workshop

Bert Roberts G4XBZ, looks into the process of designing and erecting a flexible all-band h.f. vertical antenna. All you need is an automatic antenna tuner, a fibreglass pole, a steel tape measure and enthusiasm for the project!

Fig. 1: A general impression of the assembly of components. As supplied, the fibreglass 'fishing pole' antenna is 1.14m long and 40mm in diameter and consists of nine telescoping sections (see text).



This article presents my summary of the thought processes that have gone into selecting and building an all-band h.f. vertical antenna. It also contains construction details of a simple but effective prototype antenna that can be used on all the h.f. bands for static mobile, or from a patio/temporary location.

The antenna consists of an eight metre long steel measuring tape contained within a telescopic fibreglass fishing pole, which extends from approximately one metre to eight metres in eight sections. Power is then fed to the system from the transceiver via a suitable automatic antenna tuning unit (a.a.t.u.).

When used for static mobile the tip of the antenna is approximately nine metres above the ground with the ground plane itself being provided by the bodywork of the vehicle, whilst for static operation a fan of wires is used as a ground plane.

The antenna is effective in use, with 'band hopping' being almost instantaneous. It's also very easy to erect and dismantle.

Downsizing Requirements

The need to build the antenna came about because of 'downsizing' requirements when I moved from a house to a flat. It became necessary for me to change to almost entirely mobile operation and therefore to replace my previous tree mounted wire trapped dipole, using some form of multiband h.f. antenna that could be used for static mobile and possibly on a patio, or suitably mounted on a caravan.

I decided that the chosen antenna should be easy to erect and dismantle and preferably would not need manual re-tuning between bands. Initially, I used helically wound whips, magnetically-mounted on the vehicle roof. These worked, but were not very efficient and each band required a separate antenna.

So, in an attempt to improve the signals and also become independent of using the vehicle as the 'ground', two 3.5MHz helically-wound whips were mounted 'back-to-back' so as to constitute a dipole. These were fed via 50Ω impedance coaxial cable, a 1:1 balun and the assemby successfully tuned up on both 3.5 and 14MHz.

A further modification was to mount two 7MHz whips at right angles to the 3.5MHz whips, so that 80, 40 and 20 metres could be worked without having to change the antenna. The set-up worked, but the four whips plus their mount and balun were rather heavy, especially when mounted at the top of a portable, four metre caravan television mast.

The signal reception was very good and quiet but the signal reports that were received were never very good. So, it was back to the drawing board!

All the generally used antenna designs were considered. Eventually, based upon my criteria, I decided that probably the antenna that would most satisfactorily meet my requirements would be some form of wire vertical.

Verticals & Design Issues

It was then time to look closely at vertical antennas and their design issues, bearing in mind that the best performance of a vertical antenna is achieved when it's a quarter wavelength long. However, many verticals are considerably shorter than this, needing loading and matching to be effective.

Next to be considered was the radiation pattern of a vertical antenna. This is omni-directional and has a low angle of radiation, emitting uniformly in all compass direction and also exhibits similar reception characteristics (Often referred to as 'reciprocity').

I also had to bear in mind that the operational efficiency of a vertical is dependent on a number of key factors:

A: The overall height of the antenna.
B: The nature of the ground over which the antenna is placed.
C: the efficiency of the ground/counterpoise system used.
D: The efficiency of the matching and loading elements.
E: The surroundings.

So, let's now look at the key factors individually.

Overall Height

Overall height: Generally the higher the better, as the efficiency of a vertical antenna increases with height. Additionally, the elevation angle of maximum radiation decreases with height - better for long distance (DX) working.

It must be borne in mind, however, that an half-wave vertical antenna presents a very high feed-point impedance, which according to manufacturers, is often outside the matching range of most a.a.t.u.s/automatic matching units. So, it's very important to avoid antenna lengths that are at, or near, a half-wave length (or

Fig. 2: The measuring tape's casing should be held in place via a pair of long screws terminated with wing nuts. This is so that the position of the tape can be fine tuned. The tape casing is finally clamped in place between the coupler and the base of the fishing rod, as shown in this diagram.

Fig. 3: The coating on the tape measure is removed at the area where the copper strips are clamped on to provide electrical contact (see text).

multiples of half-wavelengths) long at any of the frequencies that are to be used.

In order to avoid half-wavelengths and their multiples for the h.f. bands, antennas having heights of approximately 7.2, 8.8 and 11.8m should be considered.

Nature Of The Ground

Nature of the ground: The nature of the ground where the antenna is located is important. The ground effectively reflects the other 'half' (often referred to as the 'mirror image') of the antenna and collects the return currents to the feed-point.

In practice, most ground (other than a sea marsh) provides a very poor reflector/collector system. In order to operate reasonably efficiently it's necessary to provide an 'artificial ground' by using a series of radials.

Note: In the case of mobile operation, the body of the vehicle acts as the ground and also provides a capacitive link to earth.

Ground Or Counterpoise

The ground or counterpoise system used: Radials reduce ground losses and increase antenna efficiency. However, the information available on radials is confusing and conflicting, with regard to their number, length, diameter, insulation and as to whether they should be laid on the ground or buried!

Of necessity, when operating from a temporary location the wires have to be laid on the ground and can either be bare or insulated. In general, a large number of short radials are preferable to a few long ones.

Matching & Loading Elements

Let's now look at the efficiency of the matching and loading elements. Most verticals will be less than a quarter-wavelength long and to be effective will need to be loaded in some way. The antenna can be loaded inductively or capacitively, or with a combination of both.

Inductive loading can be at the base, middle or continuous (wire coiled around the antenna). Capacitive loading is generally provided at the tip of the antenna.

Multi-band operation requires the antenna to be matched to the transmission line and the transceiver. The matching can either take place adjacent to the transceiver by means of an a.t.u. to match the transceiver to the transmission line. Alternatively, the matching can take place adjacent to the antenna - by means of a coupling system that will match the antenna to the transmission line and thereby eliminate feed-line losses.

The Surroundings

The surroundings are important, and ideally a vertical should be mounted clear of any obstruction that could distort or absorb its radiation - especially metal structures.

My advice is that you should (wherever possible) mount your own antenna well clear of buildings and trees.

Telescopic Mast

For my purposes, the idea of a wire vertical mounted on/or wound onto a telescopic fibreglass mast seemed the ideal solution. I then purchased a telescopic fishing rod from *PW* advertiser, **Sandpiper Aerial Technology Ltd.** (See advert on page **66**).

Note: *Sandpiper confirm these are in stock, and readers should order the 9m fibreglass telescopic mast, which folds down to 1.14 metres in length.* ***Editor.***

As I had the intention of making a wire vertical, the fibreglass telescopic rod was supplied with an earth spike, two brackets to attach the rod to the spike, coil formers and sufficient wire. However, the main snag appeared to be the problem of how to wind up the wire when the antenna was being dismantled as six to nine metres of wire was bound to become tangled!

After trying various ideas, including a fishing-line reel, I decided that a more convenient arrangement would be to use a spring loaded steel measuring tape. This innovation would result in a self-winding antenna element. Of course, such an arrangement does not provide a loaded antenna but it does have a most definite advantage in convenience of use when erecting and dismantling the antenna.

Antenna Tuning Unit

Due to the wide range of wavelengths and impedances that could be presented by the antenna over the range of frequencies used, it was apparent that a wide-range a.t.u. of some form would be required. Such a device would also need to be automatic and be capable of quickly switching between bands without manual re-tuning.

The ideal solution appeared to be to mount an automatic a.t.u. (a.a.t.u) at the base of the antenna rather than mounting a tuner adjacent to the transceiver. Based upon their characteristics, I chose an SGC-231 a.a.t.u./matching unit (available from Waters & Stanton PLC).

Note: *I checked the availability of the SGC-231 with W&S, who confirm they have a few in stock. The '231 has actually been replaced by the SGC-237, which has all the same features, frequency coverage and capabilities but is much smaller then the older '231. The new model has the advantage for readers in that it's also much cheaper!* ***Editor***

Details Of Prototype

A general impression of the assembly of components is shown in **Fig. 1**. As supplied, the fibreglass 'fishing pole' antenna is 1.14m long and 40mm in diameter and consists of nine telescoping sections.

The mast has a push-in rubber cap at the top end and a screw plug at the bottom. For the suggested project it's necessary to cut a crescent shaped slot in the bottom cap - approximately 5 x 30mm - sufficiently large and curved enough in shape to allow the steel tape to pass freely through the cap, but small enough to stop the fibreglass sections falling out of the base. The fishing pole is bolted to a length of wood approximately 140mm x 1m, to which the a.a.t.u. is also bolted.

Note: The measuring tape casing should preferably be plastic rather than metal and it should also have rubber mouldings on the outside as this makes it easier to clamp and fix in position. The tape needs to be mounted in such a way that the centre line of the tape itself and the fishing rod can be aligned. This can be arranged by using thin pieces of wood (such as plywood or hardboard) between the casing and the main support.

The measuring tape's casing should be held in place via a pair of long screws terminated with wing nuts. This is so that the position of the tape can be fine tuned. The tape casing is finally clamped in place between the coupler and the base of the fishing rod, as shown in **Fig. 2**.

Most eight metre measuring tapes sold nowadays are 25mm in width. Unfortunately, this is too wide for the thin top sections of the fishing pole. So, to enable the tape to fit into the topmost sections it's necessary to trim the measuring tape down to approximately one third its width for two metres from the tip.

I found that the diameter of the top section of the pole is too narrow to accommodate anything other than a thin wire, so it wasn't used. However, in order to use the next-to-the-top section, approximately 1.1m was cut off the end of the tape and replaced with the same length of copper wire. This was then soldered on to the tape and terminated with a key-ring. (The key ring is used to pull out the first section of the fishing pole when the antenna is being erected).

Connecting The Antenna

The feed from the SGC-231 a.a.t.u to the antenna itself is via a short (200mm) length of copper wire. This is terminated with two copper strips, which fit on each side of the measuring tape and are clamped in place with a small plastic clamp. **Note:** the coating on the tape measure is removed at the area where the copper strips are clamped on (see **Fig. 3**).

Editorial suggestion: *The coatings on some tape measures can be extremely tough indeed and I have an example that's coated in Teflon. Personal experience has proved that it's best to check (using a test meter) that electrical contact has been made on to the metal tape. Also, please be aware that some long tape measures can use fibreglass tape. So, unless you wish to thread a wire through the length of the fabric - don't be caught out!* ***G3XFD***

Weatherproofing & Protection

Realising that I needed to provide protection and weatherproofing from the elements, I enclosed the SGC-231 and its connections, together with the steel tape, in a plastic wheelie-bin liner. This was fixed around the fibreglass pole by means of a bicycle tyre inner tube rolled back upon itself, **Fig. 4**.

A short length of the bicycle inner tube is first rolled on to the fibreglass tube and then left in position until it becomes necessary to protect the a.a.t.u., etc. from rain. In which case, the plastic is fitted over the assembly and the top section of the inner tube is rolled over the plastic thus making a completely waterproof rubber skirt.

Power Supplies

Power from the transceiver is fed to the base of the coupler via a length of coaxial cable. The 12V d.c. supply for the SGC-231 is supplied via a twin core cable.

The antenna is mounted, in my case, on to the back of a Land Rover (but you may not need such a vehicle!) via a length of 38mm outside diameter (o.d.) aluminium tubing, salvaged from a lighting stand. This is fixed on to a length of slotted strip bolted to the back of the length of wood, **Fig. 5**.

The arrangement also provides a suitable support for fixing the antenna to the base of a patio umbrella stand for use on the patio, **Fig. 6**.

Static Mobile Operation

When I'm operating static mobile, the SGC-231 a.a.t.u is connected to the vehicle chassis with an earthing strip. However, when I'm operating on the patio a fan of wires is used as the ground plane.

A close-up of the connections to the coupler is shown in **Fig. 7**. Looking at the diagram, and reading from left to right, the connections are: ground, r.f. input and 12V d.c. power input.

Fig. 4: A short length of the bicycle inner tube is first rolled on to the fibreglass tube and then left in position until it becomes necessary to protect the coupler etc. from rain (see text).

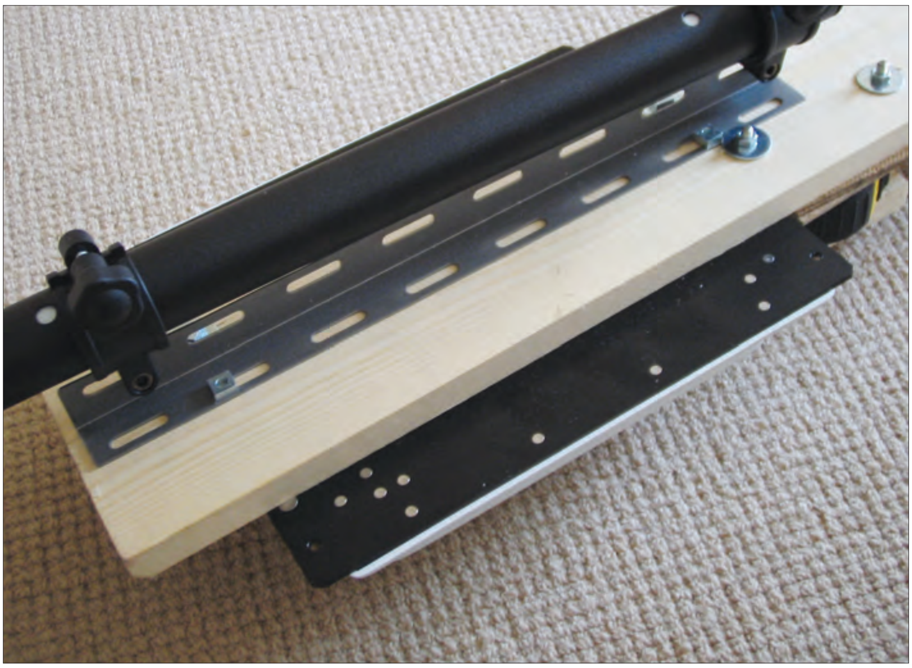


Fig. 5: The author's antenna is mounted on to the back of a Land Rover via a length of 38mm outside diameter (o.d.) aluminium tubing, salvaged from a lighting stand. This is fixed on to a length of slotted strip bolted to the back of the length of wood.

Fig. 6: The arrangement described in Fig. 5 also provides a suitable support for fixing the antenna to the base of a patio umbrella stand for use on the patio.

During temporary operation a balance has to be found between radiating efficiency and the practicality of handling a fan of long radials! The radials consist of eight wires each four metres long, soldered together at one end. Incidentally, to avoid the wires becoming entangled when they are coiled up, I feed them through six or seven grommets each 6mm in diameter.

Prior to laying out the radials the bundle of wires is first laid out in a straight line, and the grommets are pulled back to the earth terminal. The fan of wires is then laid out on the ground (preferably in a symmetrical pattern) around the base of the antenna. At the dismantling stage the process is simply reversed.

On The Air

When I'm ready to go on the air the fishing pole is extended - starting with the smallest section and each section being friction locked to the next via a slight twisting movement. Next, the 12V d.c. supply and the output from the transceiver and the ground are all connected. The antenna is ready for use.

When connected for the first time, and when r.f. is presented at the input, the SGC-231 matches the antenna to the transmission line at the frequency in use. As the unit has a non-volatile memory, the next time that frequency is used the tuning is almost instantaneous and a contact can be made without waiting to tune up. This results in very quick and effortless 'band hopping'.

Note: When first used the SGC-231 (or newer models) will make a noticeable mechanical 'clattering' sound as the system (using relays) matches the system to the antenna. The noise will continue until the a.a.t.u is 'satisfied' it has a good match. However, because of the built-in frequency 'memory', when you return to that frequency, the a.a.t.u will almost instantly provide the correct settings and you can immediately transmit. It's extremely convenient!

Packing Up

The fishing pole is collapsed in reverse order - starting with the largest diameter section, each section being separated from its adjoining section with a slight twisting motion to break the friction.

It should be appreciated that the antenna as presented is only the prototype and as such can obviously be improved and tidied up. Ideally the ohmic resistance of the antenna itself should be as low as possible, hence the existing steel tape could be replaced with a length of copper strip; but the gain in efficiency would need to be established by experiment.

Also, the overall length of the prototype could be halved by introducing a hinge arrangement between the a.a.t.u./matching unit and the fishing pole.

A simpler - and less expensive a.a.t.u. - preferably with a built in 12V d.c. supply could have been used, but it wasn't possible for me to anticipate the possible range of impedances that would have been encountered. So, the SGC-231 unit, capable of matching a wide range of impedances was chosen in the first place rather than having to upgrade later!

The prototype works well and I'm enjoying using it in its original form for the time being. I hope to work you on the air! **PW**

Fig. 7: A close-up of the connections to the author's SG-231. Looking at the diagram, and reading from left to right, the connections are: ground, r.f. input and 12V d.c. power input.