Scanner antennas

There's an old maxim about antennas that says ". . . the bigger it is and the higher you put it, the better it'll be . . .". And it's correct. But there are a few other considerations when it comes to such a specialised application as scanning. Here's a practical guide on buying, building and erecting an antenna system for your scanner, no matter what your budget.

Roger Harrison

MOST SCANNERS are supplied with some form of plug-in whip when you purchase them. These, in general, are just a simple telescopic whip with a connector on the end for desk top/mobile scanners, or a 'rubber ducky' type short flexible whip for pocket or handheld scanners. While, in the main, they do work they are inefficient at gathering in the signals you may want to hear. You can be deceived by the apparent strength and clarity of the signals you can hear on your scanner using one of these whips, but there are likely to be myriads more you're missing out on. The one major saving grace of such antennas is *convenience*. You can just plug in your scanner, plug in the whip and be on the air.

You often hear that VHF and UHF signals travel only by 'line of sight' — from the antenna to the horizon; if you can't see the antenna of the station transmitting you can't hear it. To a certain extent this is true, but not strictly so. The 'radio horizon' is actually a little further than the visual horizon — as if the earth were 4/3 the size it is, as a rough rule. However, large landforms — hills, mountains — can get in the way, but also, bending or scattering over the top of these can extend the 'horizon' somewhat. Buildings large and small will reflect VHF and UHF signals, scattering them into places you would not expect to hear them.

As mentioned in my previous article on scanning, the lower atmosphere will occasionally 'duct' VHF and UHF signals way beyond the normal horizon, some hundreds to thousands of miles. Also, the ionosphere — the electrified layers lying from 100 km to 800 km or so above the Earth — will bounce VHF signals beyond the horizon under the right conditions, sometimes half-way round the Earth.

The 'Sporadic E' layer, which forms at about 100 km above the ground at unpredictable times (hence the name) will reflect signals for distances from 500 km out to 2000 km in a single 'hop', very occasionally 3000-4000 km on multiple hops. Sporadic E propagation is most prevalent during the summer months, with a smaller seasonal activity 'peak' during mid-winter.

Around the equinoxes (21 March, 21 September), 'transequatorial propagation' conducts VHF signals across the equator for distances of 3000 km to 10 000 km or more, bouncing the signals via two dense regions in the F layer (200 — 800 km high) lying either side of the equator.

If you're interested in the unusual, or fascinated by the vagaries of propagation, then a scanner is a useful 'tool'. More information on Sporadic E may be found in ETI, May 1978, p.82, and on transequatorial propagation (TEP) in ETI, July 1978, p.112.

Polarisation

Most services using the VHF and UHF spectrum for communications want coverage in all directions over a particular area, between a base station and a number of mobiles. The simplest antenna type for this application, for both the base and the mobile stations, is a vertical whip. Such an antenna will radiate and receive in all directions in the horizontal plane.

As the current-carrying portion of the antenna is in the vertical plane, by convention the antenna will be vertically polarised because the electric field of the antenna will be vertical. Hence, the majority of signals you hear will be vertically polarised. (Well, not after they have travelled some distance, as atmospheric effects and the effects of multiple reflections confuses the polarisation of the signal so that it will be a combination of vertical and horizontal polarisation — or elliptical.)

Antenna types

For scanning applications, the first major requirements for an antenna are that it be able to receive vertically polarised signals and that it can receive more or less equally from all directions. i.e: have omnidirectional coverage. Now, because scanners cover such a wide frequency range, typically from about 40 MHz to 500 MHz or so, the antenna needs to cover a wide frequency range with more or less equal results anywhere in the range of interest. i.e: it should have a broad bandwidth.

Now that's a pretty tall order for an antenna!

Probably the most well-known, and certainly one of the best suited, types is the *discone*, the general arrangement of which is shown in Figure 1. Quite simply, it consists of a horizontal disc sitting atop a vertical cone. The connection to the elements is via a coaxial cable, the braid (or 'outer') of the cable being connected to the apex of the cone and the inner conductor to the disc, which is insulated from the cone.

The disc and cone elements can be made of solid metal, or in 'skeletal' form from metal rods or tubing. Figure 2 shows one of the popular commercially available types, the GDX-1.

The dimensions of the cone and disc are arranged in a particular way, the length of the cone side being around half a wavelenth at the lowest frequency and the diameter of the disc being 70% of that length. The included angle of the cone is generally 60°.

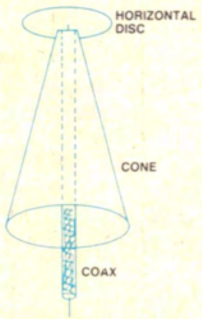


Figure 1. General arrangement of the discone antenna.

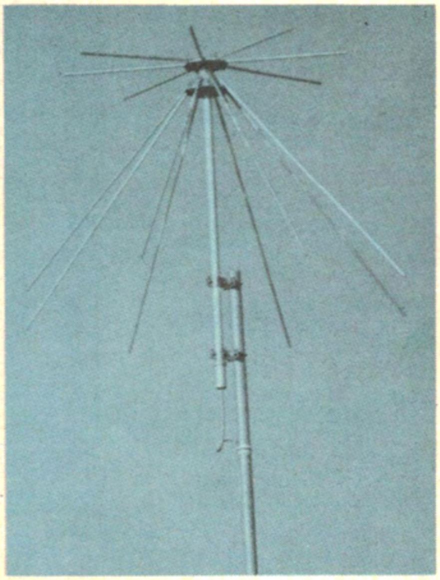


Figure 2. A popular, commercially-made 'discone', the Hoxin GDX-1. (Picture courtesy of G.F.S. Electronic Imports, Melbourne.)

Some types of discone are really stripped down to the bare essentials, the cone and disc simply consisting of three rods each, spaced 60° apart. This results in less expensive construction and a lower cost antenna. The 'Scan-X' is a widely available model featuring this form of construction (see Figure 3).

A popular form of omnidirectional, vertically polarised antenna is the *groundplane*. This consists of a single vertical element, about a quarterwavelength high, situated at the hub of four horizontal, orthogonally arranged elements, as shown in Figure 4. The four horizontal elements form a 'virtual ground', or groundplane, for the vertical element. A coaxial feedline is used, the outer (braid) connecting to the hub of the groundplane, the inner conductor to the vertical element.

The groundplane however, has a limited bandwidth, generally only +/− 5% of the designed centre frequency. However, with the addition of several shorter vertical elements alongside the original, higher frequency ranges can be covered. Tandy, for example, market such an antenna (cat. no. 20-014, 'VHF Hi/Lo, UHF Hi/Lo Ground Plane Base Antenna'). I'll show you how to build a multi-band groundplane later in the article.

The groundplane may come with a minimum of three horizontal elements, but four is more usual. Sometimes you'll see them with multiple groundplane radials, as the groundplane portion is simply a skeleton version of a solid groundplane just over half a wavelength in diameter.

If you're interested in signals from a particular area or getting improved performance over long distances, a beam antenna is required. This concentrates the area of reception of the antenna over a restricted 'window' in a particular direction, reducing the strength of signals coming from other directions. Because a beam concentratres the energy from a particular direction, it will have 'gain' compared to an omnidirectional antenna. The biggest application of beam antennas is in TV reception.

The requirement of broad bandwidth still applies and there are several types of antenna which can be used. Probably the best known, though, is the *log-periodic* antenna. The derivation of the name is quite involved, so I won't attempt to explain it here. However, a log-periodic antenna looks something like that in Figure 5.

A beam antenna will have a 'radiation pattern' or 'reception pattern' looking typically like that shown in Figure 6. If you think of it in terms of reception sensitivity, the greatest sensitivity is in the direction of the arrow, which points in the direction of the 'main lobe'.

Stations at directions off to the side of the main lobe will be received at lower strength than those toward the front. The directions either side of the main lobe peak where the signal strength falls to a half defines the 'beamwidth'. A very large beam, with many elements, may have a beamwidth of 20°, a smaller model, perhaps 80°.

Well to the side of the antenna there may be some minor 'side lobes', with very deep 'nulls' between them and the main lobe. Signals in the direction of the nulls will be severely attenuated.

A further lobe will be found to the rear of the antenna, but sensitivity will be well down compared to the main lobe, as it will be with the side lobes.

Naturally, if the antenna is directional, you'll need to be able to point it in any desired direction, unless you're interested in signals from one general direction only. That's what an antenna rotator is for.

In general, omnidirectional antennas for scanning cost $50 to $100, whereas a beam antenna will cost upwards of $100.

There are many makes and models of antenna rotators on the market, for TV antenna systems and for ham or commercial antenna applications. They cost from around $150 upwards. In general, an antenna rotator will consist of a motor assembly which mounts on a mast and a remote control unit which contains the control switches and a direction indicator. (See Figure 11, later.) ▶

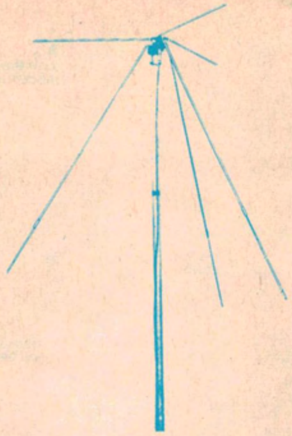


Figure 3. The Hoxin 'Scan X', a truly 'skeletal' form of the discone antenna. This one is sold by many scanner equipment suppliers.

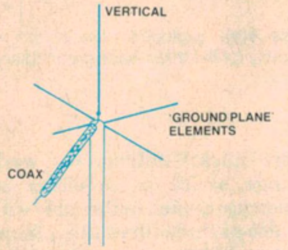


Figure 4. General arrangement of the 'groundplane' antenna.

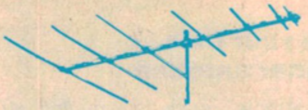


Figure 5. A typical log-periodic beam antenna (horizontally polarised here). All the elements are split in the centre and 'cross-connected' to the next in line.

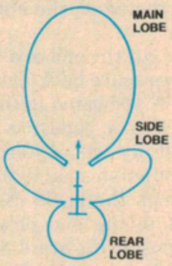
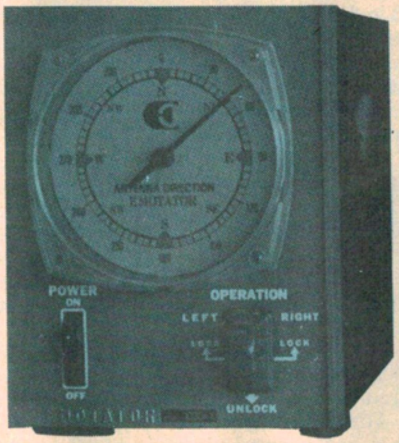
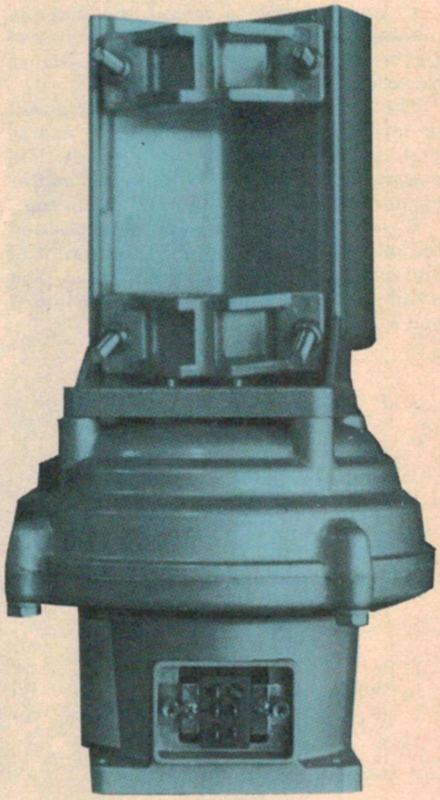


Figure 6. The 'radiation pattern' of a typical beam antenna, showing how the sensitivity varies to signals from different directions. To pick up a signal from a particular direction, the antenna is rotated so that the main lobe points in the desired direction (where the signal will be strongest).





Beam rotator. A typical beam rotator comprises a motor housed in a weatherproof enclosure (to which the beam is attached) — on the right — and a remote control and indicator unit — on the left — sited at your operating position. This is the Emotator 103SAX, available from G.F.S. Electronic Imports, Melbourne.

Build your own scanner antenna

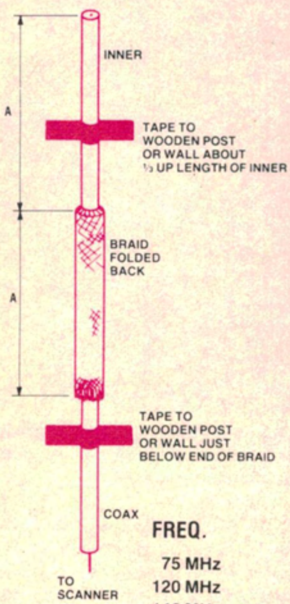
For a simple, quick, cheap and effective antenna that will cover a single band of interest, it's hard to beat the 'coax dipole' shown in Figure 7. There is an antenna type known as the *coaxial dipole,* and this is a version constructed on the end of a piece of coaxial cable.

To make it, cut the end of a length of coax square then measure back along the sheath the distance 'A' indicated in the accompanying table. Using a penknife or modellers' scalpel, carefully cut around the cable through the outer sheath, to the braid. Take care not to nick the braid. Slit the sheath from the cut to the end of the cable and remove it, exposing the braid. Starting at the end of the cable, gently push the braid back toward the end of the sheath, bunching it up, then work the braid loose along its length toward the end of the sheath. Carefully undo a little of the braid at the end and roll it back on itself, then roll back the braid, pulling it down over the sheath to form the antenna as illustrated in Figure 7.

If you're going to mount the antenna outdoors, seal the cable at the turnover of the braid using a silicone compound such as Silastic.

The antenna may be taped high on a wall or taped to a pole mounted outside and as high as you can conveniently get it. Use electrical insulation tape. It doesn't matter too much if the inner droops a bit at the top.

If you're taping it to a wall inside, position the antenna as high as possible; keep it vertical and away from large masses of metal. You could suspend it using nylon fishing line, if you wish.



FREQ.	A
75 MHz	935 mm
120 MHz	585 mm
146 MHz	480 mm
160 MHz	440 mm
470 MHz	150 mm

Figure 7. The 'quickie' coaxial dipole. It's simple, but only covers one band (and three times that frequency band, but not as well).

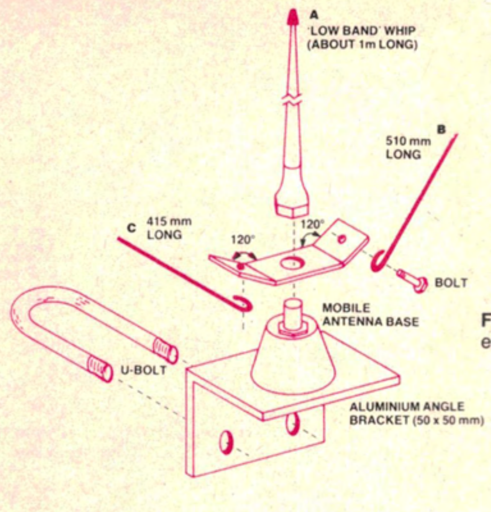


Figure 8(a). Exploded view of the whip radiator assembly for the three-band groundplane.

This 'quickie' antenna will work well over a range of 5% or so either side of the frequencies quoted in the table with Figure 7, and also at three times those frequencies.

Figure 8 shows the construction details for a multi-band groundplane for base station or mobile use. The principal element is a commercially available 'low band' VHF mobile whip about one metre long. This mounts to a standard VHF antenna base mounted on a piece of aluminium angle bracket. A small piece of aluminium plate about 20 mm wide by 40 mm long is drilled and bent as shown in Figure 8a. This holds the two side antennas, B and C, at an acute angle to the main whip (about 30°). These can be fashioned out of heavy gauge (e.g: 16g or 18g) bare copper or steel wire. Each has a small loop at the end so that it can be bolted to the bracket secured under the low band whip.

A dual groundplane system is used for base station applications. These are fashioned out of 9 mm (3/8 inch) aluminium tube bolted to a 50 mm (or larger) diameter aluminium mast which can be as long as you please. Figures 8b and 8c show the dimensions and general construction, 8d shows the completed antenna.

The angle bracket holding the vertical element is secured to the mast just above the groundplane elements using a U-bolt.

Attach a length of coax to the antenna base, seal it with a silicone compound such as Silastic and you're ready to go on the air!

For mobile operation, dispense with the groundplane elements and mount the angle bracket to a roof-rack bar using two small U-bolts positioned vertically, side by side. Alternatively, if you have a VHF mobile antenna base already mounted on your vehicle, the three elements could be mounted to it in the same fashion as shown in Figure 8a.

This antenna will cover channels within quite a few MHz of 70 MHz, 140 MHz and 170 MHz — which covers some of the more popular bands. It will also work on the UHF band, but perhaps not as well as a good UHF antenna.

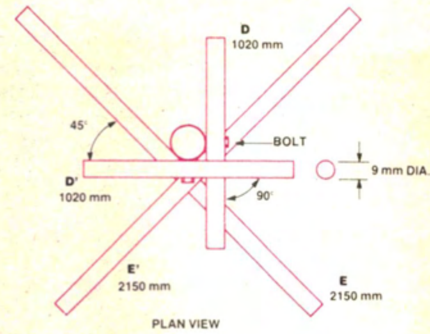


Figure 8(b). Plan view of the two sets of groundplane elements.

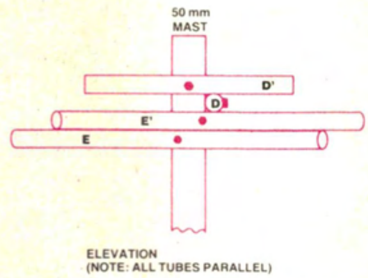


Figure 8(c). Elevation view of the two sets of groundplane elements.

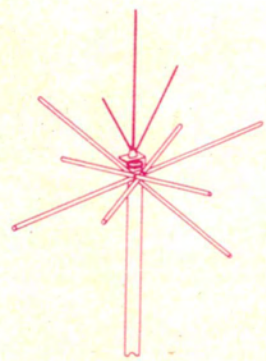


Figure 8(d). Overall view of the finished three-band groundplane.

Erections

"The higher you put it, the better it'll be . . .", says the old maxim, but there's no need to go to extremes. Really good results can be obtained simply mounting the antenna on the roof of your house. A 30 metre high tower is hardly in keeping with the cost of your scanner!

No matter what sort of antenna you're using, mount it in a conveniently high position and as clear of nearby objects or structures as you can. If you're mounting it somewhere on your house, then simple, low cost TV antenna type fittings can be used, as illustrated in Figures 9 and 10.

When contemplating where to mount the antenna, you'll need to keep in mind that the shorter the run of coax feedline you can get, the better off you'll be. Any sort of feedline has losses — that is, it will attenuate the incoming signals to some extent, and the loss increases with increasing frequency. Thus, the shorter the length of feedline, the less the loss incurred.

The sort of feedline commonly used is known as 'RG58' or 'RG58C/U'. Buy a good quality make — it will have less loss than that made for CB applications. RG58 is about 6.5 mm

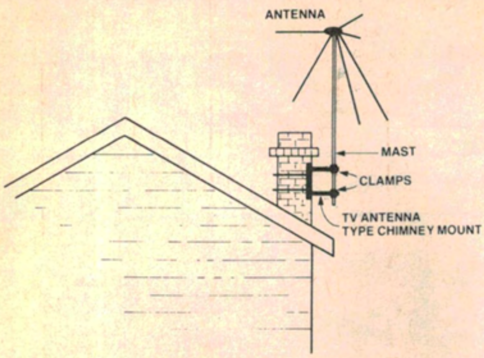


Figure 9. Mounting a scanner antenna on your chimney, using TV antenna type fittings. The mast should be no taller than two or three metres.

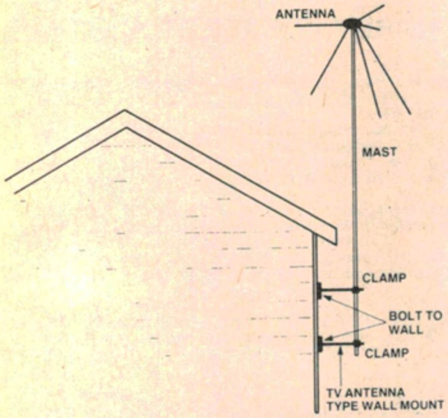
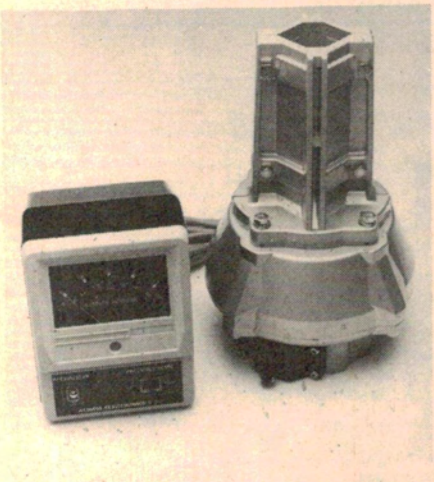


Figure 10. Mounting a scanner antenna from a wall, again using TV antenna type fittings. The mast could be up to 4m tall but, if so, keep the wall mounts about a metre apart.

in diameter and has a loss of around 16 dB per 100 metres at 100 MHz, 24 dB/100 m at 200 MHz.

However, the larger diameter coax cables have lower loss figures. These are generally 10 mm in diameter and two common types are RG8 and RG213 (sometimes with the /U or C/U suffix). These have losses of around 6 dB/100 m at 100 MHz, 9 dB/100 m at 200 MHz. As you can appreciate, despite the extra cost, the larger diameter coax is a better proposition when long feedline runs are involved.



Another rotator. This beam rotator is a 'medium duty type, by Alinco, model EMR-400. It is available from Imark Pty Ltd, Melbourne.

If you intend using a beam antenna, the mounting configuration shown in Figure 11 is recommended. The mast can be mounted using the techniques shows in Figures 9 and 10, but make sure the total mast length is no longer than about three metres, otherwise it may not take the wind loading that the beam antenna will exert on it.

When mounting a beam antenna, ensure that it can rotate freely and that the beam is mounted to the mast at the point of balance. The short section of mast between the beam and the rotator must not be metal, otherwise it will interfere with the operation of the beam. It should be at least as long as the longest element, or slightly longer. You can use ABS pipe, as suggested, or a wooden mast here (suitably treated against the effects of the weather. i.e: paint it with an exterior epoxy lacquer, such as Estapol).

The feedline should have enough slack in it so that it is not strained by the operation of the rotator, yet not too much that it flaps violently in the wind, which will prematurely wear it. Tape it securely to the mast sections above and below the rotator.

Well, that concludes this short guide to scanner antennas; good listening!

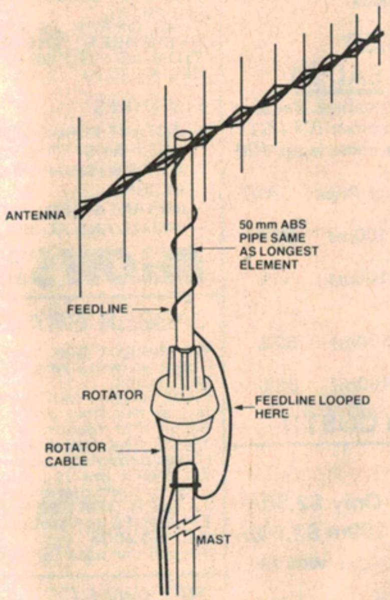


Figure 11. General arrangement for mounting a beam antenna and rotator. The mast should be supported no further than 1½m below the rotator.

Some references

Here are a few books which contain useful further reading on the general subject of antennas. They are not listed in any preference order.

The ARRL Antenna Book, *The American Radio Relay League, 1982.*

Vertical Antenna Handbook, Capt. Paul H. Lee, USNR, K6TS, *Cowan Publishing Corporation, 1974.*

The Radio Amateur's VHF Manual, *The American Radio Relay League, 1982.*

VHF-UHF Manual, Fourth Edition, *G.R. Jessop, G6JP, RSGB Publications, 1983.* ●