Antenna to Ionospheric Matching

By Vladimir Ademov

THE AUTHOR HAS made an academic study of amateur radio antennas and has come to the following conclusions.

1. The antenna should be efficient, enabling communication with any part of the world using the lowest attenuation which path propagation conditions will allow.
2. The antenna should be able to operate on any of the high frequency bands allocated for amateur radio.
3. The antenna should be unobtrusive because most amateur radio operation is from suburban sites.

THE PROBLEM

EXISTING METHODS of obtaining antenna efficiency is to use a horizontal antenna as high as possible. This produces multiple vertical lobes, some of which have a low enough angle to match into long distance ionospheric propagation conditions; this results in a considerable waste of radio frequency energy. The author has observed the most commonly used method of overcoming this inefficiency is to use a gain array, normally a Yagi-Uda. This in turn makes the antenna large and obtrusive. Further, designing such a structure to operate on more than one frequency band results in compromise. Another method is to use a vertical antenna. Although the angle of radiation of a vertical antenna is low, it has only one lobe and will only match a limited set of ionospheric conditions. In addition, a considerable proportion of the radio frequency energy is absorbed in the surrounding earth and nearby metal objects. Vertical antennas are also more susceptible to man-made noise.

HYPOTHESIS

THE AUTHOR HAS noted that the vertical angle of radiation is determined by interaction with the ground. The horizontally polarized image in **Fig 1** is in antiphase and cancels the radiation along the earth's surface. At appreciable wave angles the path length from the image is greater by a distance of:

$$2h \sin \theta$$

resulting in a phase difference of:

$$4h \sin \theta/\lambda \text{ radians.}$$

The image of a vertically polarized antenna (**Fig 2**), is in phase and supports radiation along the surface.

Matching the transmitter to the antenna is well documented. However, matching the antenna to the ionosphere has been ignored in the literature, or dismissed as insignificant. All that is required is an antenna system whose main vertical angle of radiation is controllable.

How can this be done? In the case of vertical polarization over a hypothetical perfect earth, the 'optical' nature of these waves can be clearly seen. The author believes that this earth/antenna interaction can be exploited to match the antenna optimum ionospheric propagation. This hypothesis is testable as follows:

1. Modifying the profile of the earth where the earth currents are greatest.
2. Modifying the profile of the antenna.
3. Adjusting the height of the antenna to operate in conjunction with 1 and 2. The hypothesis predicts that the exact angle of radiation can be produced to suit the ionospheric propagation path in use to exploit the chordal hop propagation phenomenon.

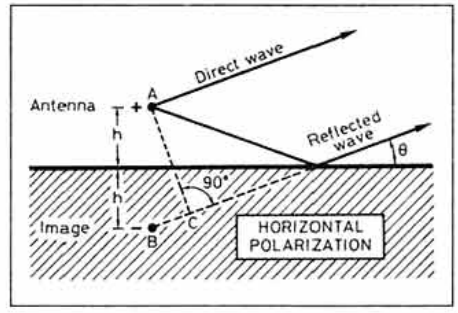

Fig 1: Horizontal polarization.

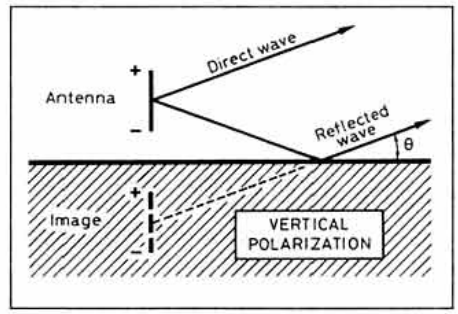

Fig 2: Vertical Polarization.

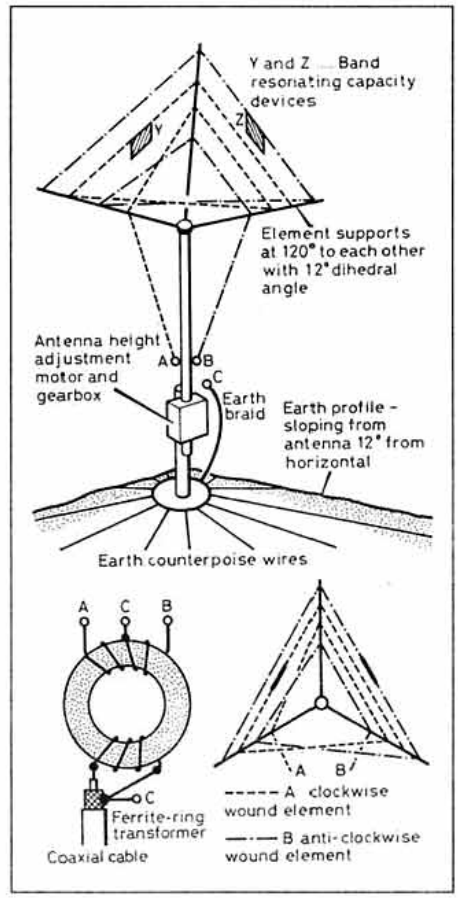

Fig 3: Antenna construction details.

SOLUTION AND DESIGN METHODOLOGY

THE DESIGN EVOLVED BY the author is illustrated in **Fig 3**. It comprises two counter-clockwise triangular coil configurations on the same support. Although most of the element length appears horizontal, the polarization is vertical because the elements are in fact large diameter coils; the same principle as the DDRR antenna. The system is made to resonate on the appropriate bands by the use of capacity elements; often referred to as 'hats' in literature but the author found the devices illustrated more effective.

The elements are fed by a matching system, invented by the author, and known as Y-front matching. The Y, formed by V wires connecting the elements and the braid to the counterpoise, is connected using a ferrite ring transformer illustrated in Fig 3. For the purpose of experimental work a wire earth system was arranged. A manual system of height adjustment was devised with suitable counterweights to allow easy adjustment. The maximum field strength at specific vertical angles could then be measured.

RESULTS

THE ANTENNA WAS ENERGIZED using a transmitter/receiver sounding system devised by the author. A pulse of radio frequency energy was transmitted and any returned energy was displayed on an oscilloscope. As expected, short range signals were reflected back from the ionosphere when the antenna's height was low.

As the height of the antenna was increased these short range signals disappeared. At one critical height a weak signal was observed having a 77mS delay, and is illustrated in **Fig 4**.

This weak signal was found to be the transmitted signal having travelled round the world in a chordal hop mode with very little at-

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tenuation. Obviously, this angle of radiation only has to be modified slightly to allow communication with any part of the globe.

The final design will have the height remotely controlled by an electric motor and gear box. The control unit for this height system can then be calibrated in terms of distance, with appropriate corrections for propagation conditions, of course.

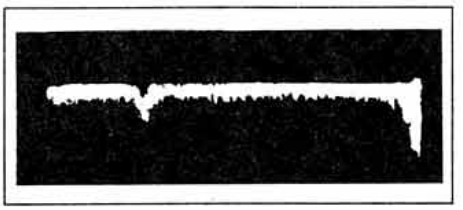
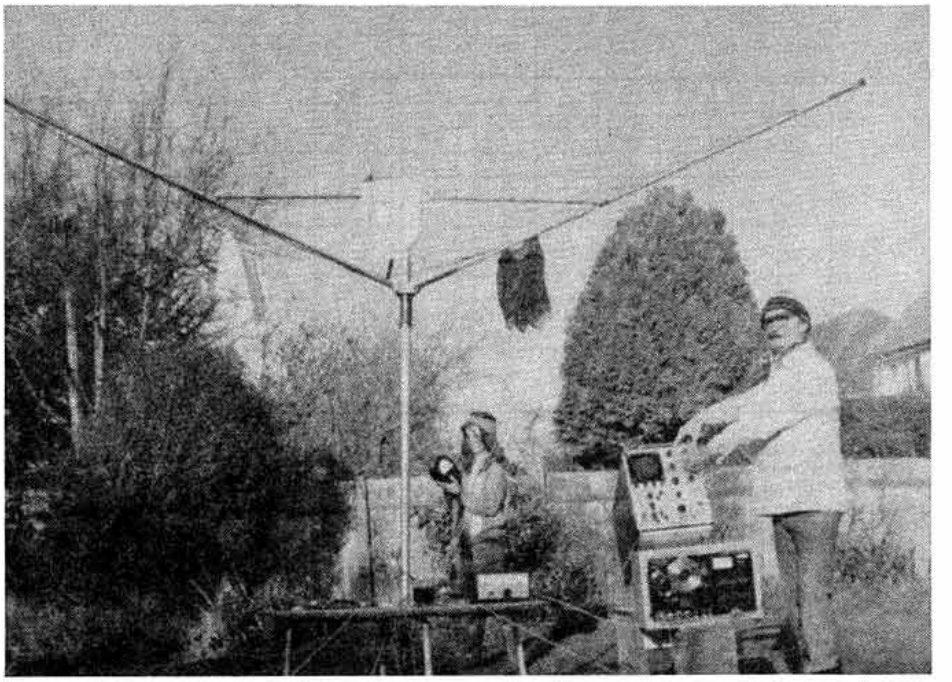


Fig 4: Oscillogram of echo signal.

CONCLUSIONS

THESE EXPERIMENTS PROVED completely the author's hypothesis and a patent for the antenna design has been applied for.



The author and his assistant demonstrating the use of his equipment in the back garden of his home.

The reader will note that no data is given regarding feed impedance, relative polar diagrams and antenna dimensions following normal practice in some literature describing experimental work. If the reader feels that this has raised more questions than it has answered then he should be philosophical; there is still a wide open field for the experimenter.

ACKNOWLEDGEMENTS

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