AERIAL OVERVIEW

MF ANTENNA OPTIONS; PART ONE

Modern antenna design must satisfy the broadcaster's twin requirements of technical and cost efficiency. Faced with the task of resolving these sometimes contradictory demands, the designer of antenna systems has a number of options. In part one of this two part series,* Brian S. Collins, *Technical Director of C&S Antennas, provides an overview of current practices in design and construction of transmitting antennas in the MF Band, and examines the selection of an antenna to perform a given task.

THE service area of low power stations is usually limited by groundwave attenuation to a radius of a few tens of kilometres from the transmitter. At night the service area of the transmitter will shrink owing to signals from other distant stations using the same channel being received by skywave propagation. Skywave propagation is not significant during daytime as any signals radiated skywards are absorbed by the strongly ionised 'D' layer of the ionosphere.

The control of the vertical radiation pattern (VRP) of the antenna for a low power station is not of direct concern in determining the service area. In certain locations, control of the VRP may be needed in order to limit skywave interference to some other low power co-channel station. In the more general case the prime consideration for low power stations is to provide a low cost antenna of reasonable efficiency. Reference to Figure 1 shows that the field strength laid down by a mast radiator increases only slowly as the antenna height is increased. By contrast the cost of guyed masts and self-supporting towers increases rapidly with increasing height.

In considering a higher antenna with increased gain, the extra cost incurred must be compared with the cost of the extra mains supply power consumed and the cost of extra installed transmitter power. It is unusual for masts much higher than 90 degrees to be economic

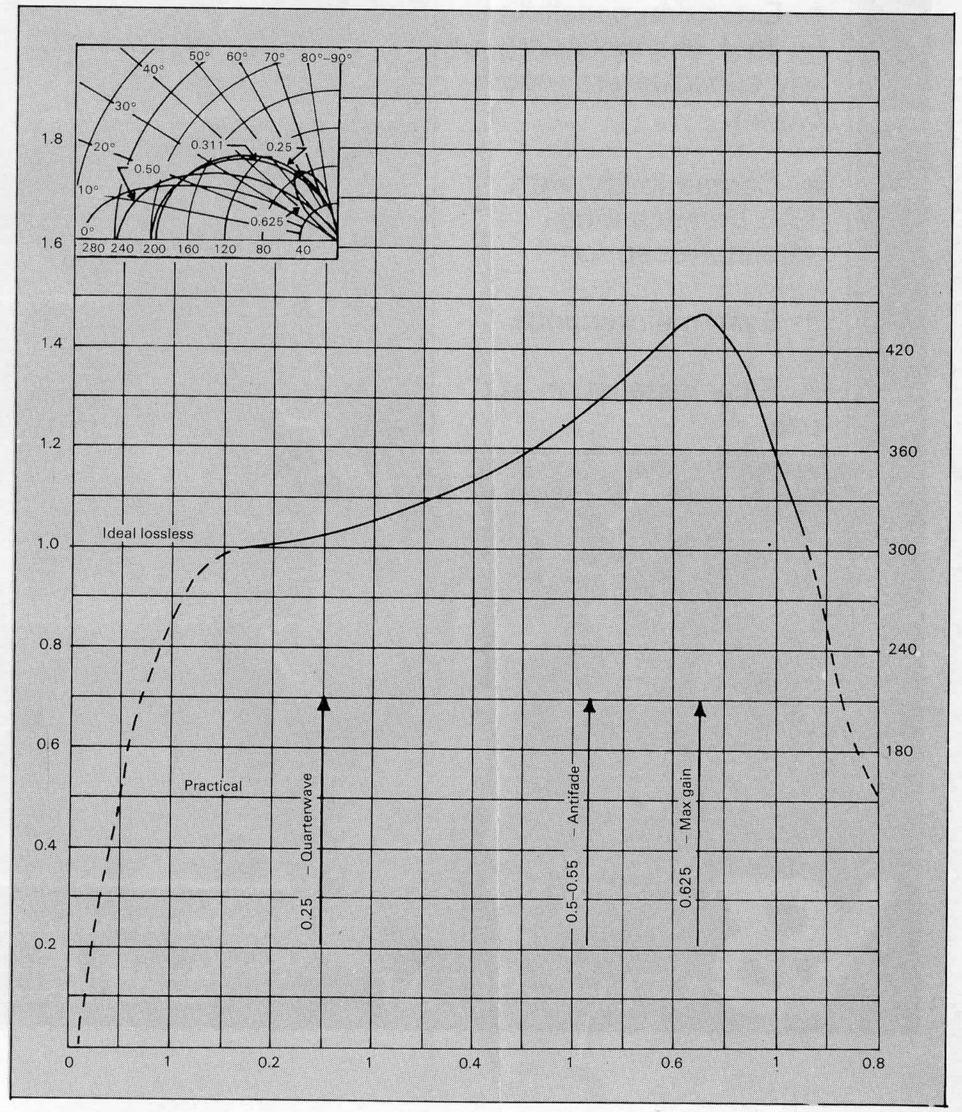


Fig. 1 Field strength of lossless vertical radiators at 1 km for 1 kW input.

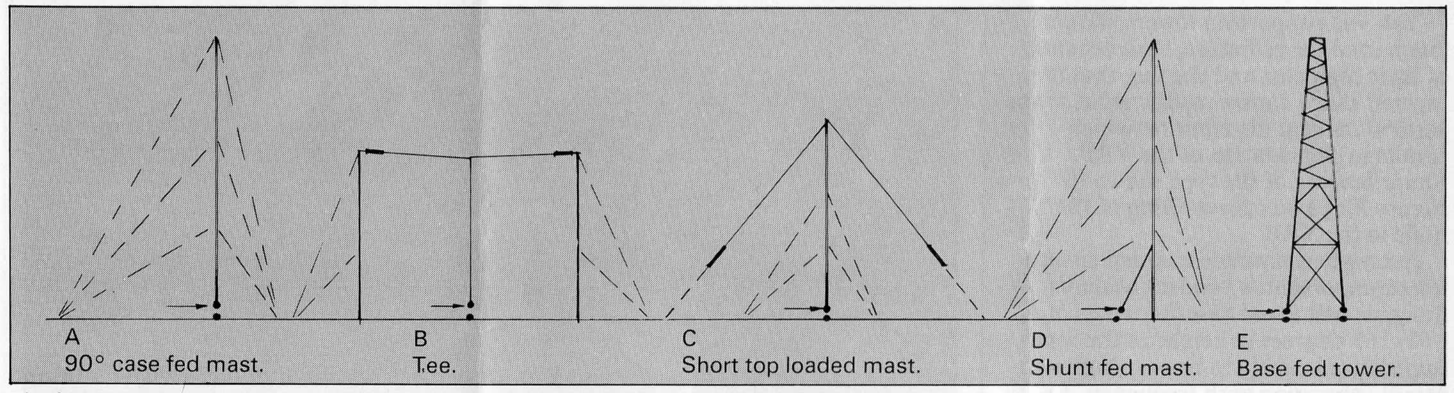


Fig. 2

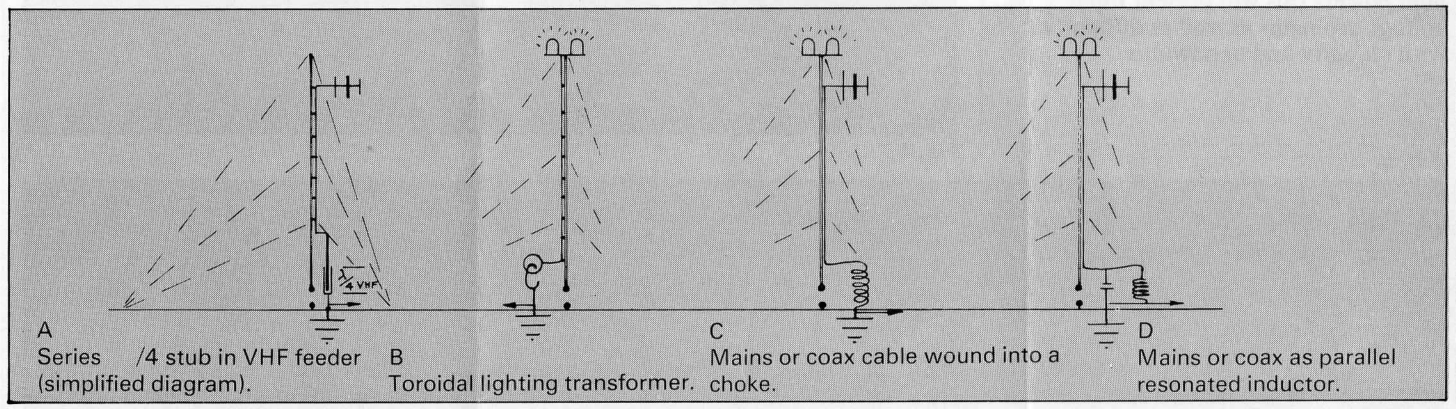


Fig. 3

until the transmitter power is high enough for night time fading to limit the service area — this problem is unlikely to be important for powers less than about 50 kW in Europe or slightly lower in areas of the world where the MF band is less noisy.

Some commonly used omnidirectional radiator systems are shown in Figure 2. A comparison between the economics of these configurations generally shows the short capacitively-loaded antenna to be most cost-effective. When correctly designed, this configuration is able to provide surprisingly high efficiencies from short antennas. The Tee (b) is useful when high efficiency is needed near the lower edge of the band, but the two masts required to support it make its cost relatively high. The Tee is of greatest economy when three transmissions must be radiated: the insertion of a base insulator into the supporting masts produces three antennas from this compact configuration which may be used independently if suitable filtering is provided.

The shunt-fed radiator at (d) is attractive when aircraft obstruction lighting or VHF antennas are to be erected on the MF antenna, as no isolation circuits are required. Alternative methods for feeding lighting or coaxial feeders up base-insulated masts are shown in Figure 3. These methods may be used to allow new services, for example Band II radio transmitting antennas, to be added to existing MF radiators.

The choice of method depends on the number of services to be isolated, and on the relative powers of the MF and VHF services. Thus a 1 kW MF service could conveniently be isolated from a 10 kW VHF service using arrangement (a). The series quarter wavelength choke sections would have an adequate voltage flashover rating to avoid problems at MF. However a 10 kW MF service together with a 1 kW VHF service would use arrangements (c) or (d), as it will be easy to form a coil from the relatively thin coaxial cable required to carry the VHF service. Circuits (c) and (d) are easy to combine with an MF antenna tuning unit (ATU) and both have the advantage of providing a path for static charge to leak from the antenna to earth.

High power MF antennas may be intended for extended groundwave coverage of the territory around the antenna, or for skywave coverage of a more distant target area.

The importance of the VRP of the antenna may be seen from Figure 4. A transmitting antenna at 'A' provides a groundwave signal at location 'X', but it also illuminates the ionospheric 'E' layer at the angle of elevation which propagates to 'X'. If the fields received at 'X' by these two modes are of comparable magnitude, fading will occur as the relative phases of the two modes change. It will also be seen from Figure 4 that no signal is propagated by the 'F' layer because of the null in the VRP of the transmitting antenna at 'A'. If we require fade-free reception at 'X' we must suppress either the skywave or the groundwave component. The usual approach to this problem is to design the antenna at 'A' to radiate as much energy as possible at low angles of elevation to avoid exciting unwanted skywave modes.

It is important to analyse the propagation characteristics of the path to the target area, to establish the relative importance of the various possible ionospheric modes for the path. The antenna is then designed as far as possible to excite the wanted modes and avoid exciting troublesome ones.

The basic so-called 'antifade' radiator is a parallel sided stayed mast around 190 degrees high, insulated and fed at its base (Figure 4(a)). Variants (c) and (d) provide improved VRP's but at the expense of additional complexity. (b) has been used to avoid the need for highly-stressed high voltage insulators at the mast base: however this is achieved at the cost of increasing the feed voltage and increasing losses in the antenna compared with (a). The use of top loading (e) allows some height reduction, and can be made variable to allow some on-site adjustment. A shunt-fed, grounded tower is an attractive element for radiators in large very high power arrays in which the VRP is secured by the interaction of several elements and the most important feature of each driven element is its simplicity.

MASTS & AERIALS

Tall self-supporting towers are not much used for radiators, both because of their high cost and the fact that the tapered shape causes modification of the vertical current distribution which results in degradation of the VRP. Shunt feeding of the type shown in Figure 2(d) also causes filling of the nulls in the VRP.

Even when antifade characteristics are unimportant, a prudent antenna designer will avoid base-fed masts of 150–165 degrees in height as the input impedance is likely to be very high and rapidly changing with frequency. At high powers this will present input voltage problems as well as difficulties with stability and bandwidth.

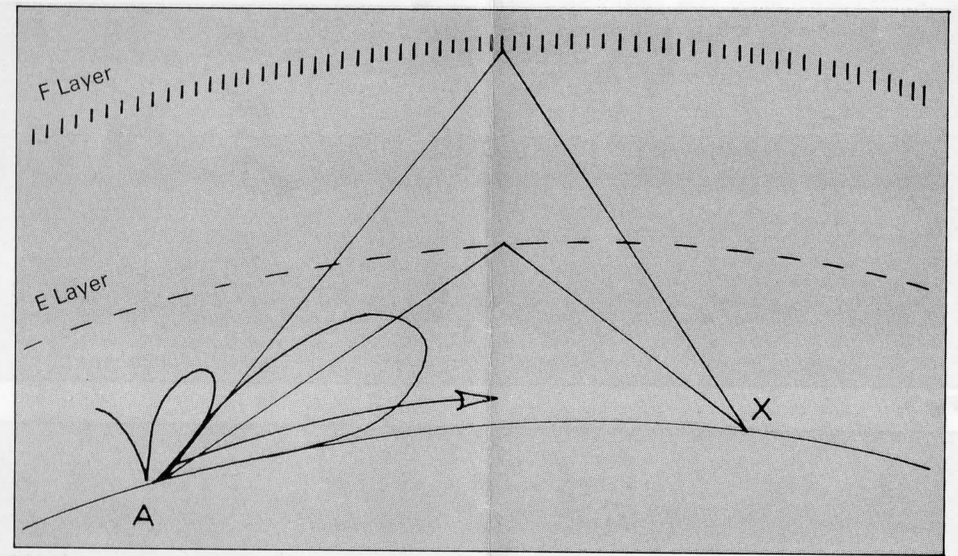
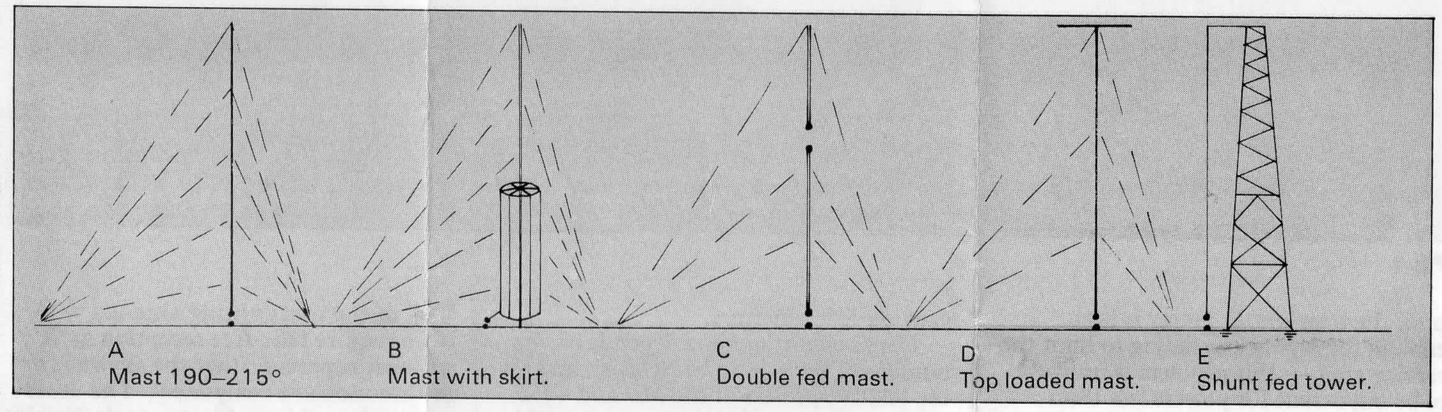


Fig. 4

Fig. 5



The use of a simple directional antenna is often worthwhile even when not required for co-channel protection, as for example when a transmitter is situated near the coast. A useful increase in field strength inland may be obtained relatively cheaply by using a low gain directional transmitting antenna.

The most basic directional array comprises a single driven radiator with a passive reflector or director. A simple, convenient antenna for low power use is provided when a reflector in the form of a simple sloping wire is supported from the top of a mast radiator. A series reactance connected between the bottom of the sloping wire and earth allows some adjustment of the current in the wire and hence of the horizontal radiation pattern (HRP) of the antenna. Further control of the radiation pattern is obtained by the choice of the coupling between the driven element and the parasite. This array does not allow antifade characteristics to be achieved in the vertical plane: this is the reason for its general confinement to low power applications. Back-to-front ratios can be chosen in the range 5 dB to 20 dB or more.

When it is desired to use electrically shorter structures, for example in the lower part of the MF band, two separate masts are often employed, one as a driven radiator and the other as a parasitic reflector or director. Both masts may be made considerably shorter than a full quarter wavelength. Slightly higher forward gains can be obtained by the use of a director rather than a reflector.

For high power stations, where antifade characteristics are needed, two radiators each 190–215 degrees high are used. Both radiators are usually driven, the complex current ratios and radiator spacings being chosen to produce the desired HRP. Owing to the action of mutual impedance between the radiators, the input impedances of the two radiators will generally be unequal and the power fed to the two radiators will be different — even when equal currents are required. A power division and phase shift network is required to divide the transmitter output power between the two radiators. An instrument to measure the complex ratio of the radiator currents is provided for this type of array: monitoring loops are installed on the masts or near their bases to provide samples of the radiator currents for measurement. Greater accuracy is obtained using mast mounted loops 10 m or so above ground level, as the sample of the mast radiating current so obtained is less disturbed by currents associated with base capacitance and other local effects. Feeders from mast mounted loops require isolation at the mast base and are therefore more expensive than loops mounted on a separate pole.

Facilities are provided for varying the relative amplitude and phase of the radiator currents. For low powers variable inductors are often used, but at higher powers variable vacuum capacitors are more reliable in service.

As the requirements of the HRP specification for an antenna become more complex, the number of radiators needed to synthesize the pattern increases. Many of the array configurations to be found in the standard texts pre-date the wide availability of computer facilities. The antenna design engineer now has a much wider choice of array designs and can readily examine the effect of modifications on his initial proposals. Most importantly, he can investigate the effects of inaccuracies both of physical construction and of excitation on the VRP and HRP of an array. This analysis can be performed both at the channel centre frequency and at the sideband edges. ☐

Next month – practicalities.