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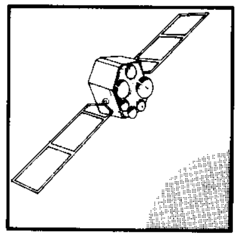

New antennas for the 1.5GHz band

Crowded radio communication bands have necessitated the opening up of new bands. A major expansion of the use of the 1.5 GHz band is now under way. New antennas have been designed to optimise the potential capacity of this band for the future

by B. S. Collins

The last 25 years have seen very rapid growth in the use of radio circuits for speech, data and control links. As the available spectrum in each band has been filled, users have been allocated channels in bands with progressively higher frequencies. The shortage of available allocations in the VHF 'high band' (165-174MHz) led to increased use of the UHF band (450-470MHz) during the 1960s and 1970s. This band is now in turn under severe pressure with the result that private users are increasingly being allocated frequencies in the 1.450-1.535GHz band. The spectrum available in this band has been divided to provide facilities for wideband and narrowband services and includes allocations for duplex and back-to-back link operation. The current band plan is shown in Fig. 1.

Subband	Type of use
A	short-range mobile telemetry and telecontrol links
B	fixed links for telephony, telemetry and telecontrol (up to 36 telephone channels or equivalent in frequency division multiplex)
E	fixed links for telephony, telemetry and telecontrol (up to 8 telephone channels or equivalent in frequency division multiplex)
F_1 F_2	fixed links for telephony, telemetry and telecontrol (single or 1 + 1 telephone channels)
	unidirectional links
G	doppler and sensing devices
X	reserved band
F_3	fixed links for telephony, telemetry and telecontrol (single on 1 + 1 telephone channels) (use of the F_3 subband is subject to Home Office confirmation)

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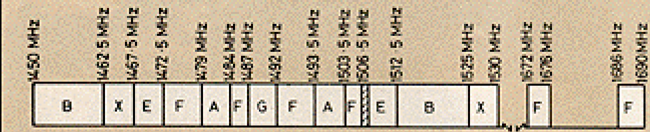

1 Private user fixed and mobile radio services in the 1450-1690 MHz band

Crowded bands

From the outset it is clear that in due course the spectrum available in this band too will become fully occupied, and it will become impossible to accommodate further users. However, as propagation in this band is essentially limited to line-of-sight paths, the same frequencies may be reallocated within a comparatively short physical distance. (In fixing the co-channel protection ratio, allowance must also be made for abnormal propagation conditions affecting small proportions of total

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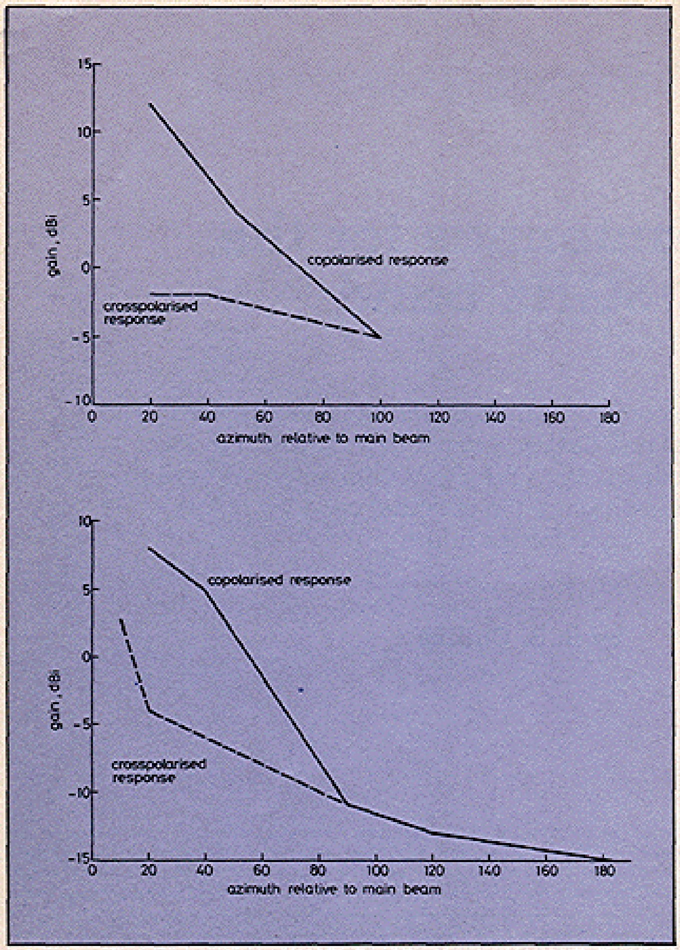


2 Antenna radiation pattern for: (a) 1800 MHz E and F subbands; (b) 1500 MHz B subband

3 Slow-wave antenna for low-capacity subbands prepared for inspection prior to despatch

operating time.) To maximise the potential number of users who could simultaneously use a single-frequency without suffering any mutual interference, each transmitting antenna should ideally radiate no power except in the direction of the receiving antenna at the other end of the same link. Furthermore, the power radiated in that direction should be no more than will produce the signal-to-noise ratio at the receiver which is necessary for the type of service to be provided. The total antenna gain on the link should be optimally divided between the transmitting and receiving antennas. Antennas which radiate only in a single direction with nothing radiated elsewhere are unrealisable, and so a more practicable compromise is needed.

Antenna size

As the required beamwidth of an antenna is reduced, so the physical aperture required to produce the beam is increased. Thus, the frequency management ideal in which all users have very narrow beam antennas is not practicable because of:

• the cost of large antennas the cost of structures capable of maintaining sufficient pointing accuracy in high winds

• the unacceptable appearance of large numbers of large antennas in towns and countryside areas.

Thus the planners' ideal for maximum utilisation is self defeating. A wider view of the problem is needed.

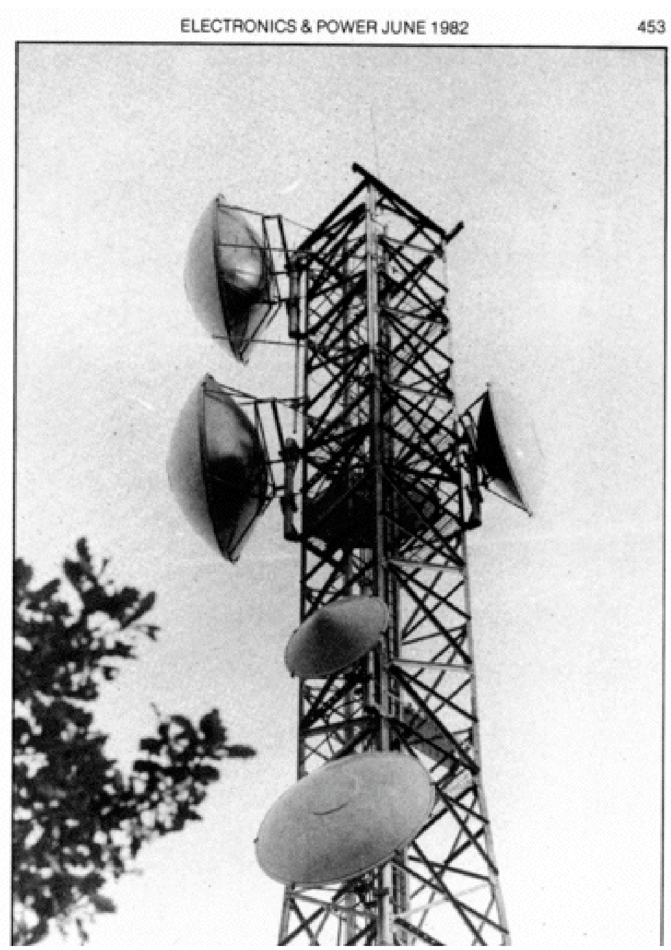
In the United Kingdom, consultation between the communication equipment manufacturers, system users and the regulating authority (the Home Office) has resulted in the publication of agreed specifications for the equipment to be used on links. Conformity with these specifications is mandatory and type approval tests are carried out by the Home Office on new types of equipment.

The specifications for antennas describe the maximum levels of sidelobe and rearlobe radiation together with minimum cross-polar performance both on and off axis. Maximum effective radiated power (ERP) and maximum transmitter power are also specified. Permitted ERP is further controlled as part of the licence conditions for each link. The specification template for antenna radiation patterns reproduced in Fig.2 represent an effective compromise between performance and the penalties of over-specification referred to above. With the exercise of ingenuity on the part of the antenna-design engineer, the specification can be met and exceeded by robust and reproducible antennas which can be made and sold at a price which is attractive to the user.

Low-capacity sub-bands

Antenna gains and directivities specified for low-capacity links can be provided by a variety of relatively simple types of antenna. Conventional Yagi (properly Yagi-Uda) arrays can be used and are capable of providing adequate forward gain and sidelobe suppression. However, the elements of a Yagi are very small — 120-150mm long at l.5GHz — and the antenna needs a radome to provide protection from the weather. The design of a suitable driven element to excite the Yagi poses problems, especially as the variation in the performance of a large production batch must be small enough to guarantee that all the antennas will meet the specification for input VSWR as well as conforming to the radiation pattern template. Radomes have a large effect on VSWR, forward gain and sidelobe levels and the tolerances associated with the construction and fitting of low-cost radomes are poor.

The antenna illustrated in Fig.3 uses a radically different approach. An easily reproduced slow-wave structure is illuminated by a simple launcher excited directly from the unbalanced coaxial input connection. The whole antenna is supported by and encapsulated in polyurethane foam moulded in situ. The result is a strong, lightweight weathertight antenna which is well suited to large-scale production and whose electrical performance is defined to within close limits. The centre of mass of the complete antenna lies only a little in front of the rear casting and so a single rear-mounting clamp gives adequate support. The well-defined mounting configuration avoids degradation of the performance of the antenna when it is mounted at the user's installation.



High-capacity sub-bands

The standard of antenna performance specified for high-capacity systems is much more demanding. The specified maximum rear-lobe level precludes the use of simple arrays of Yagis, even if they were provided with multiple reflector elements.

To minimise the windload of a large antenna it is attractive to consider the use of an array of straight or curved rods as a reflecting surface. Unfortunately the field leakage through a rodded reflector is unacceptably high and causes infringement of the template in the rear hemisphere. A solid or perforated sheet reflector must therefore be used; this may be a plane surface illuminated by an array of elements, or a curved surface illuminated by a single element. The low levels required for the sidelobes in the forward hemisphere demand good control of the illumination of the antenna aperture.

For these reasons the antenna adopted is a solid skinned paraboloidal reflector with a suitable feed assembly. As the main reflector is only a few wavelengths in diameter, Cassegrain geometry is not used because the subreflector would either be too small or would cause too much blockage of the main reflector aperture. In either case the result would be low gain and inadequate control of sidelobe levels. The challenge offered by the specification template is greatest for antennas of the smallest diameter (1 2m) where diffraction effects from the feed and reflector edges are most troublesome as a relatively large proportion of the total power impinges on these regions.

The antennas for this application are1 2m, I 8m and 2 4m focal plate paraboloids fitted with a slot/reflector prime-focus feed. The feed is connected to the input socket at the rear of the reflector by a precision coaxial line section. It is enclosed in a glass reinforced plastic (GRP) cover which provides mechanical support as well as protection from the weather. A GRP radome is available to cover the whole antenna. As well as providing further weather protection, the radome reduces the windload on the antenna by improving the shape presented to the wind.

A more mundane but equally essential feature of the design is an adaptable mounting arrangement with easily adjusted panning facilities to allow the pointing direction of the antenna to be set up quickly. Long threaded studs

allow independent adjustment in the horizontal and vertical planes. The polarisation of the antenna may be set up and accurately adjusted from the rear of the reflector. As access to the front of the reflector is difficult and requires specialised equipment — especially in the case of the 2 4m diameter antenna — the mounting of the entire feed assembly has been designed so it can be withdrawn from the rear without disturbing any adjustment of the antenna.

The development of new antennas to meet the evolving requirements of users is a process making continuing demands on the skill and ingenuity of antenna engineers. This article has indicated the background to the new requirements in the 1.5GHz band and the way in which engineers have responded to them.

Brian Collins is Technical Director of CSA (C&S Antennas Ltd), Knight Road, Rochester, Kent, ME2 2AX, England