Engineering for the fourth u.h.f TV channel in the United Kingdom

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Summary The shape of the plan to provide a fourth United Kingdom u.h.f TV channel is outlined in this article, and topics discussed include timing, coverage density and the composition of the new equipment being provided.

The transmitters to be used introduce a new type of klystron which results in savings both in equipment cost and building space required. Cost benefits also arise from extensive standardization of equipment layout. A new supervisory system includes microprocessors and software-based techniques.

A stringent vestigial sideband specification has been laid down for Channel 21, used here for the first time in the UK, and the article describes how this has been met by the use of Rotamode filters

Many additional channel-combiners are required and Rotamode filters are to be supplied for this requirement also.

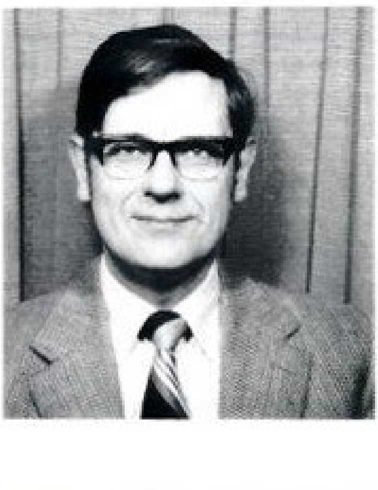
Emphasis has been placed on stability of performance in the design, and the importance of environmental conditions in achieving this has received special attention.

Derek Chambers

Derek Chambers, M.I.E.E.E, A.M.I.E.R.E, joined the Independent Broadcasting Authority in 1970 from the BBC, where he had been engaged on a number of projects. Among these was the design and construction of u.h.f relay stations and v.h.f radio stations in the Transmitter Capital Projects Department. Prior to that, he spent several years in industry, where he worked on the research and development of a wide range of electronic projects. His early work with the IBA was as a Senior Engineer working on u.h.f transmitting aerial systems, and in 1972 he became Head of the Authority's new Local Radio Project Section. In 1976 he became head of the Transmitter Project Section in the Station Design and Construction Department. He is married with two children and lives in Surrey.

R. Wellbeloved

Mr. Wellbeloved began his career with The Marconi Company in 1956 and following a period of several years working on radio and television transmitter installations, he joined the Independent Television Authority (now the IBA) in 1965. He was promoted to Head of Transmitter Section in 1967 and was responsible for the provisioning of transmitters and transposers for the u.h.f 625 line network from 1967 until 1973. He was then promoted to his present post of Head of Transmission Group where as deputy to the Head of Station Design and Construction Department, he is involved with the full range of procurement activities for the new fourth channel transmitting station network and the Regional Operations Centres.



Introduction

At the Stockholm Conference of European Broadcasters in 1961 the United Kingdom was allocated groups of four u.h.f channels for use at common transmitter locations in order to provide national coverage for four programme services. Fifty-one medium and high power main stations (20–1000kW e.r.p), plus several hundred relay stations are required to provide this coverage.

Prior to 1964 when the second British Broadcasting Corporation channel (BBC2) opened as a 625-line colour service on u.h.f, both BBC1 and the Independent Television programme (ITV1) were broadcast in black and white on 405 lines only. To enable this obsolescent standard to be phased out, duplicated 625 line BBC1 and ITV1 services in colour were opened on u.h.f in the late 1960s. These three u.h.f programmes are now available to approximately 98% of the population.

Both broadcasters are presently involved in extending this coverage to as much of the rest of the community as practicable by the installation of a further 200–300 small relay stations. Use of the fourth, unallocated, u.h.f channel remained uncertain until Spring 1979 when the Independent Broadcasting Authority was authorized to install the necessary transmission facilities. This article describes some of the planning and engineering aspects of this major project.

Planning

It is estimated that two to three years will be required to set up the programming arrangements and administration for the new channel, and to provide the necessary programme distribution circuits throughout the country. Unlike the present ITV1 service, distribution for the new channel is envisaged as being via a fixed network emanating from a studio centre in London with separate contribution circuits, some of which may be shared with ITV1. This network is expected

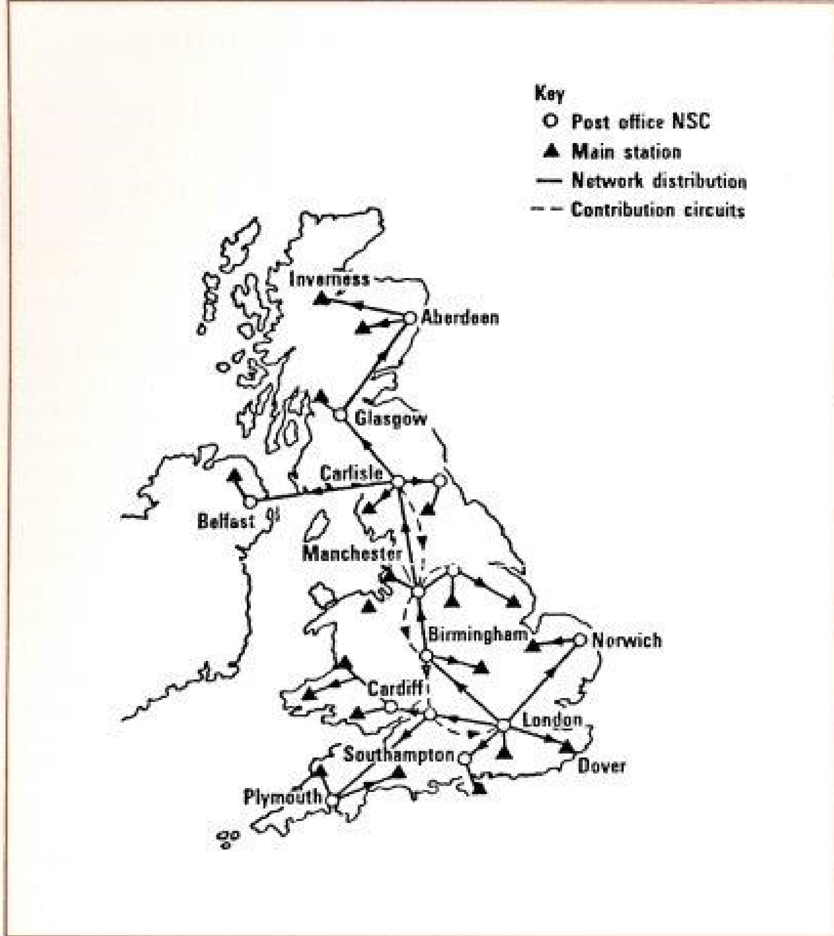


Fig. 1. Distribution network and contribution circuits for the fourth channel

to be as shown in figure 1 and the majority of circuits are planned to be in operation by mid-1982.

Construction of the transmitter network has been planned on the assumption that the first group of stations will open simultaneously. The target is to provide at least 70% coverage of each of the existing ITV regions throughout England, Scotland and Northern Ireland, but with 90% coverage in Wales. This requires a total of 31 main stations and 81 relay stations to be ready for service in November 1982.

The most important factors considered have been:

a) the engineering resources available;
b) the capacity of manufacturers to supply, install and commission transmitters;
c) the desirability of standardization of equipment types within geographical maintenance areas wherever practicable;
d) the interdependence of certain stations where the programme feed is to be provided by off-air reception;
e) the need to delay and phase-in the construction of those stations operating on Channel 21, at the lower edge of Band IV, to permit maximum time for the design, development and manufacture of the special filters and group delay correctors required;
f) the involvement of the BBC, who are responsible for providing buildings and other common facilities at 50% of the sites which they own under the terms of the existing site-sharing agreement between the two broadcasting authorities;
g) the need to minimize the number of equipment types and power levels.

The plan finally evolved required the installation of transmitters to start in March 1981 and to continue at a rate of two per month. Thus, by September 1982, 31 main stations should be completed. There is then a three-month period allowed for contingencies and commissioning and testing of the complete stations via the programme distribution circuits which should then be available. Transmitter installations start again in December 1982 at a rate of 12 main stations and 35 major relay stations per year. It is expected that, towards the end of the decade, the fourth channel coverage will approach that of the three existing services.

This construction programme is clearly a major undertaking, and two major UK transmitter manufacturers were awarded contracts in October 1979: One of these was Marconi Communication Systems Limited.

Installations by the two manufacturers have been carefully interleaved throughout the construction programme. In certain geographic areas, such as Northern Ireland and the north-east of Scotland, groups of stations will be equipped with transmitters from a single manufacturer. In this way, optimum use can be made of the manufacturer's resources and of the Authority's staff who will be overseeing and participating in installation work and subsequently maintaining the equipment in service.

Main station design philosophy

All the original sites were initially designed and developed for four-channel operation with primary power capability (at either 11kV or 415V three-phase) sufficient for four services. In all but three cases, the existing antenna systems were designed to accept the fourth channel. In the majority of cases, building extensions are necessary to accommodate the new transmitters, although this was allowed for in the original building design.

Figure 2 is a simplified schematic diagram of a typical four-channel main station. The new equipment comprises transmitters, combining units, programme input equipment and a new supervisory system. As with the existing ITV1 network, the new transmitters will be unattended and fully automatic in operation. Also, at each station, microprocessors and software-based techniques are being introduced into the supervisory system.

The existing ITV1 network uses only two transmitter configurations. Parallel transmitters are used at the more important stations and passive reserve systems are employed at less important stations. In the latter case, a three-klystron arrangement is used, i.e a normal vision and sound transmitter with a common vision/sound klystron amplifier as reserve. The disadvantage

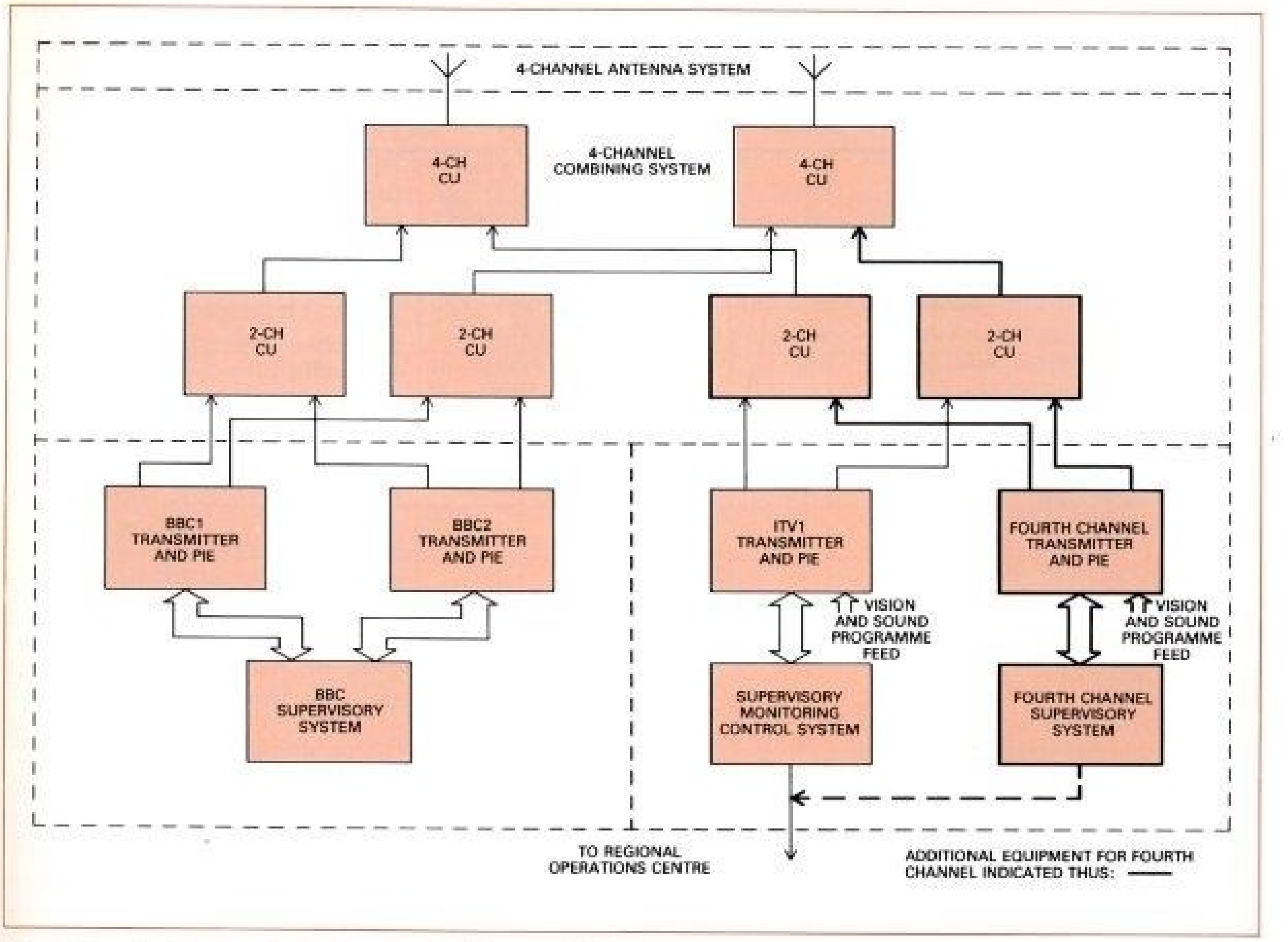


Fig. 2. Schematic diagram of typical 4-channel u.h.f transmitting station

of this arrangement has been the five-minute warm-up time required for the reserve klystron, although the reliability of the transmitters has been such that loss of programme from this cause has been minimal. For the fourth channel, it has been decided to continue with these same two transmitter configurations but to employ a new type of klystron which does not require a warm-up period.

Considerable emphasis has been placed on minimizing building costs and achieving the highest possible degree of standardization of equipment layout. It has also been possible to reduce drastically the floor areas required by adoption of the new klystron which is physically much smaller than earlier types.

Technical aspects

Choice of klystron

For the ITV1 network, integral five-cavity klystrons were used at stations equipped with 25kW and 40kW transmitters in parallel. The higher gain of these devices was essential because of the low power output (1–2W) available from solid-state drives in the late 1960s. Conventional, external four-cavity klystrons with a power capability of 10–11kW peak sync were used at lower-power main stations. The technical performance and operating lifetimes of both these types of klystron have proved very satisfactory, and clearly it would have been advantageous for the IBA to equip the new fourth channel network with these well-established devices, adequate spares holdings of which already exist. However, alternative designs of transmitters based on a new range of Valvo external cavity klystrons[1] were also offered, and, after careful economic and technical evaluation, the latter were selected for the following main reasons:

a) lower capital and operating costs resulting in an overall lower 'cost of ownership';

b) smaller size which permits compact and highly standardized transmitter layouts;

c) only two types of klystron with standardized accessories are required for the complete transmitter network;

d) air cooling of the body and magnet assembly eliminates water pumps;

e) elimination of the reserve klystron warm-up time by use of the 'black heat' technique. A reduced heater voltage of 4·5V permits simultaneous application of the beam voltage and full heater voltage of 5·5V when required for service. Black heat operation does not affect the 'running hours' warranty;

f) the power capability of 15kW peak sync, for the smaller klystron, is more convenient than 10–11kW for the range of power outputs required.

The London main station, Crystal Palace, alone requires parallel 40kW transmitters, and the existing type of integral five-cavity klystron (EMI Varian VA950HA) will be used there.

Channel 21

In the United Kingdom, the Home Office has laid down a stringent specification for radiation on the lower vestigial sideband of Channel 21. This is to minimize possible interference to fixed and mobile radio services operating in the portion of the spectrum

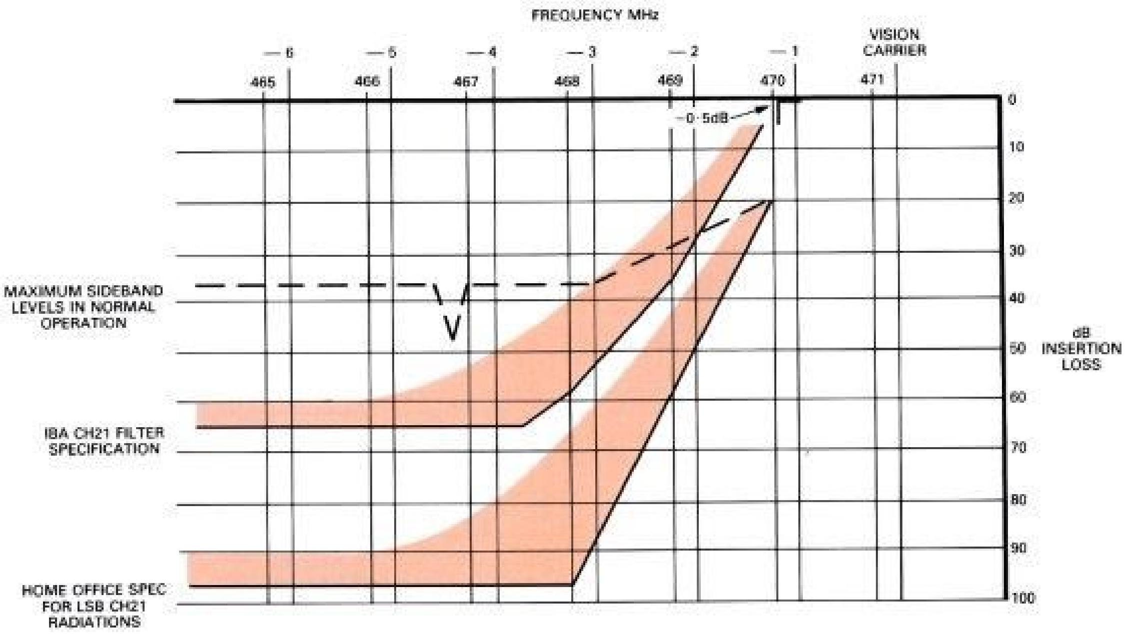


Fig. 3. Channel 21 lower sideband filter specification

immediately below Channel 21, i.e 465–468MHz.

The klystron is a far-from-perfect linear amplifier and generates non-linear products when operated close to its saturated output capability, as is necessary for high efficiency. Measurements have shown a maximum level of regenerated signals on the lower sideband of −38dB below peak sync. These add to the normal system I v.s.b levels as shown in figure 3. Additional attenuation must be provided by special filters in the output of each transmitter and it can be seen that the requirement is for −64dB at a frequency of 3·75MHz below vision carrier. With a maximum passband loss of 0·5dB, a very rapid transition from 'pass' to 'stop' is necessary, and this introduces considerable group delay variations at low frequencies. Experiments and computer predictions show that these can be satisfactorily corrected within the i.f drive. An overall group delay performance within ±30ns is thereby achieved.

A contract was awarded to Marconi Communication Systems Limited for the supply of nine-section Rotamode[2,3] filter networks and the appropriate i.f group delay correctors to meet these stringent requirements. The prototypes of these have already been built and shown to meet the specification at low power.

Channel combining equipment

Rotamode filters are also being supplied as part of the channel combining equipment. As may be seen from figure 2 additional combining equipment is required to enable the fourth channel transmissions to be radiated from the existing antenna systems. In the case of a four-channel antenna, two additional two-channel combiners are required, and the Rotamode solution is cheaper and more compact than the classical Lorenz ring arrangement.

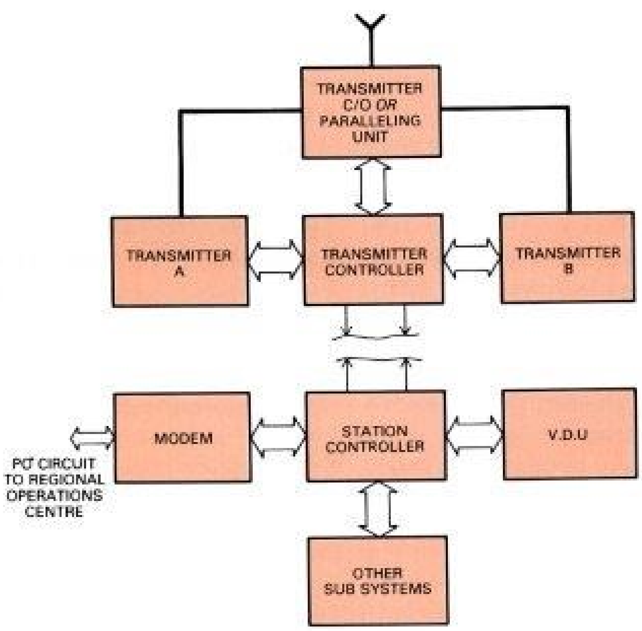


Fig. 4. Simplified diagram of station supervisory system

Transmitter and station controllers

As already mentioned, microprocessor-based transmitter and station controllers[4] are to be used at each main station. The general arrangement is shown in figure 4. The transmitter controllers are being supplied as part of the transmitter contracts and will be programmable to deal with either parallel or passive reserve systems. The interface to the station controller is by means of optical fibres and ASCII code. By means of a high/low-speed data switch the transmitter system can be constructed and tested independently, using a standard teletypewriter or v.d.u.

Sub-systems supervised by the station controller also include: automatic performance measurements on the interval test signal (ITS); programme input switching, telemetery; diversity switching (where installed); data logging (as required).

The use of programmable transmitter and station controllers offers a number of advantages. It provides a readily definable interface between the transmitter systems being supplied by the manufacturers and the station supervisory system designed by the IBA; it also effects cost savings. The arrangement is much more flexible than the present hard-wired systems. Future equipment or system changes, such as provision of local programme 'opt-outs', will be simplified.

Stability of performance

The IBA, in common with other broadcasters operating large networks of unattended transmitting stations, is constantly striving to achieve the highest possible stability of performance. The use of automatic monitoring equipment, with preset alarm limits which are signalled back to the Regional Operations Centres,[5] has added emphasis to the need for a very high degree of stability in order to avoid unnecessary alarms, especially in tandem chains of stations. Accordingly, the specification for fourth channel transmitters requires that they remain within 'acceptance limits' for a period of three months, without adjustment.

Experience has shown that one contributory factor to performance stability is that of the environmental conditions in which the equipment operates. The designs and specifications of fourth channel equipment and building layouts take account of earlier problems. The transmitter cooling systems incorporate motorized louvres and sensing thermostats to utilize transmitter waste heat during winter periods and provide increased ventilation in summer. The specification requires that, with an external ambient temperature range of 0–18°C, the ambient temperature range within the transmitter hall and plant room shall be limited to 18–24°c. Above 18°C (i.e in summer conditions) the temperature rise in the transmitter hall and plant room shall be limited to 6°C above the outside ambient temperature.

Other factors

Fire protection

After detailed consideration, it has been concluded that complex fire protection arrangements are not worthwhile, because they are unlikely to give sufficiently early warning at an unattended transmitting station and may impair station reliability because of false alarms.

However, heat sensing cable, which is used to initiate transmitter shutdown at 68°C, has been incorporated in existing transmitters and is specified for the new fourth channel transmitters. Experience to date has indicated that this simple arrangement is highly reliable and one case of over-heating has already been detected by this means.

Safety Considerations

Substantial revisions have been made to many IBA specifications with the object of stressing the safety aspects and, in particular, the transmitter specification has been brought into line with the latest International Electrotechnical Commission (IEC) Standard as defined in Publication 215, 1978 edition.

Teletext performance

The new transmitters must, of course, be capable of radiating teletext signals with minimum degradation. The specification is defined in terms of 'eye-height' and requires that, with an input data signal having an eye-height of 95% or better, the eye-height on the demodulated output signal shall be not less than 82%. Experience with existing transmitters has shown that degradation of teletext eye-height is primarily due to inadequacies of the group delay corrections.

Conclusions

This article has highlighted various aspects of the engineering of new transmission facilities for the fourth channel in the United Kingdom. With the construction of 31 main stations and 80 relay stations in three years, the project represents an extremely heavy workload for the Engineering Division of the IBA and is probably one of the most ambitious broadcast transmitter construction programmes ever attempted. Planning for a co-ordinated opening of all stations simultaneously, rather than sequentially, affords an added degree of freedom and flexibility. This enables optimum use of the resources of the two main United Kingdom transmitter manufacturers, as well as those of the IBA. A number of technical challenges, such as the problems of operating on Channel 21 and the introduction of microprocessors for transmitter and station control, must also be met within this very strict timescale.

Acknowledgement

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