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RECENT DEVELOPMENTS IN UHF AND MICROWAVE TERRESTRIAL TELEVISION IN THE UK

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Abstract. Following the allocation of commercial franchises in 1997 the UK is expected to launch a UHF digital terrestrial television service in late 1998. A shortage of suitable taboo channels restricts the use of repeaters. Gaps in coverage area may be filled by 40 GHz MVDS technology.

1. Introduction

The recent development of high speed computer chips has made the real time transmission of digitally compressed television pictures a practical reality. It is now possible to compress a standard definition studio quality picture which has been digitized at 216 Mb/s to a transmission bit rate of less than 40 Mb/s with no loss of picture fidelity. This lossless Fourier Transform compression technique has proved popular for tapeless post production video editing in which video sequences are stored on a computer hard disk rather than on tape.

The commercial television industry sees a much wider market for more powerful "lossy" compression systems in which the transmission data bit rate is further reduced to about 4 Mb/s for a standard definition picture. The quality of the received picture is, admittedly, no longer as good as at the studio camera but is probably the same as todays's PAL or SECAM colour pictures.

There is a divergence of view between European and American broadcasters.

- The American broadcasters are interested in high definition television as a competitor to the cinema. Although a studio HDTV signal requires a transmission bit rate in excess of 1,000 Mb/s tests show that lossy compression algorithms can produce good results at about 20 Mb/s.

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- The European broadcasters are more content with their 625 line pictures and are more interested in choice. They prefer to offer multiple standard definition television SDTV pictures which might be combined five or six at a time in order to fill a 20 Mb/s data stream.

Initial production quantities of 20 Mb/s domestic set–top digital television decoders (for either multiple standard definition TV or single high definition TV pictures) are expected to cost about \$ 500 – 700. It is expected that, at first, the broadcasters will subsidise the production cost of these units so that potential viewers can buy the new digital television service for about US\$ 300.

For both multiple SDTV and HDTV there are two principal engineering issues to be solved. The first is a baseband issue: the effectiveness and efficiency of the video compression algorithms which are used in the encoder – decoder. The second is a radio frequency issue: the choice of the digital modulation system and the deployment of a transmission network. This paper describes how the United Kingdom has set about implementing a robust digital transmission system for multiple SDTV terrestrial UHF and microwave distribution.

2. The current UK UHF analog television transmission network

The United Kingdom is currently served by 51 principal high power UHF transmitter locations together with more than a thousand repeater sites. Each transmitter site broadcasts four or five separate television channels – BBC 1, BBC 2, ITV and Channel 4. The principal transmitter sites use horizontal polarization at power levels of between 100 to 1,000 kW per channel whereas the UHF repeater stations use vertical polarization at power levels of between 2 W and 10 kW per channel.

Although VHF was used for the original 405 line black and white TV service which commenced in 1935 it has not been used for colour television broadcasting. The 625 line colour TV network was originally designed as a four channel system and employs a 3:4:3 channel spacing wherever possible. Improved transmitter diplexer technology later permitted 3:3:4 channel spacing to be used. The four channel service is available to 99.4 percent of the 57.5 million population of the UK.

Until recently UHF channels 35, 36 and 37 have not been used for television broadcasting. Channel 36 serves two purposes. It is still used for the 50 cm airport radar service and is the channel of choice for the output of UK video cassette recorders. After much debate channel 37 has been assigned to a new fifth national TV channel (Channel–5) which uses conventional analog

PAL technology. The UK government has recently allowed Channel–5 to use UHF channel 35 for a period of 5 years (until 2002) in order to improve the coverage of this new channel from about 55 to 70 percent of the UK population. However, many areas of the UK, particularly along the south coast of England near France and Belgium, will remain unserved because congestion makes frequency coordination extremely difficult.

3. The proposed UK digital television system

The technical challenge is quite straightforward. How many terrestrial 20 Mb/s data streams – the digital television multiplexes – can be introduced into the crowded UHF television band without causing interference to existing analog television services? In short the answer is six.

3.1 Taboo channels

The trick is to introduce these new digital services at power levels which are much lower than existing analog transmitters and in channels that, until now, have remained unused – the so called Taboo Channels. In the UK a number of suitable taboo channels have been identified for use by digital television (DTV) at all of the 51 main transmitter sites and at 30 of the 1,000 plus repeater sites.

3.2 Roof top aerials

At most sites it is possible to use the hitherto unused adjacent channels of each analog transmission. At some sites, however, digital channels have been allocated away from the main analog group. It is as yet unclear whether existing roof top aerials can provide sufficient performance at frequencies outside their design range or whether viewers will be required to replace their existing aerial with a wide band design.

3.3 OFDM parameters

The BBC and NTL research teams have considered three probable digital modulation schemes, each providing a different level of service. These are shown in Table 1 below.

In line with European thinking each scheme assumes that many separate Orthogonal Frequency Division Modulation (OFDM) carriers will fill a European 8 Mb/s television channel. The BBC/NTL proposal is for 1705 separate carriers, the so called $2k$ proposal. Work is also in hand for the possible later introduction of an $8k$ scheme which is favoured by other European broadcasters. The OFDM reference parameters are shown in Table 2 below.

Table 1. OFDM candidate systems

	Type of Modulation	Code	Failure Point dB	Bitrate Mb/s
System 1	16 QAM	1/2	12.0	12
System 2	16 QAM	3/4	16.5	18
System 3	64 QAM	2/3	20.0	24

Table 2. OFDM reference parameters

Number of carriers	1704
Modulation	16 QAM or 64 QAM
Outer coding	3/4 or 2/3
Duration	224 μs
Guard interval duration	7 μs
Symbol duration	231 μs
Carrier spacing	4.464 kHz
Spacing between max/min	7.61 MHz

3.4 Interference

The interference criteria are quite strict. Interference must not be caused:

- More than 5% of the time to existing UK and Irish analog TV service.
- More than 1% of the time to Continental analog TV services
- More than 1% of the time to other UK digital TV services.

3.5 Predicted coverage

To predict the coverage of a digital television service area is extremely difficult. Transmission is characterised by a very rapid transition from near perfect reception to no reception at all. Until there is wider experience of real working systems it is difficult to decide whether to be optimistic or pessimistic. UK population coverage assessments are based on the predicted field strength in each 1 km square of a digitized map. Two different methodologies have been used to predict coverage.

a) The cut off prediction method. All the population who live in areas in which at least 90% of 1 km squares are assumed to be served.
b) The proportional prediction method. The proportion of the population which is predicted to receive the minimum field strength level in those areas where at least 50% of the 1 km squares are assumed to be served.

The two figures appear quite similar at high percentage predictions but differ substantially at the extremes of the coverage area. It proved possible to find four suitable taboo channels at all 81 UK sites. Further investigation indicated that a further two taboo channels could be found at most of the 81 sites. The BBC/NTL predictions for the 81 UK transmitter sites are shown in Table 3 below.

Table 3. Predicted percentage coverage of UK population by a) cut-off method and b) proportional method

Required C/N (dB)	1st Taboo (Best)		4th Taboo		6th Taboo (Worst)	
	a)	b)	a)	b)	a)	b)
12.0	96	97	92	95	73	83
16.5	93	95	93	88	62	74
20.0	89	93	82	89	53	66

It is worth noting that the population coverage figures are based on the use of an outdoor receiving aerial which is properly oriented and set at a height of $10m$. Although 90 percent of UK homes do have such an aerial it is also common for "second" sets" to have no connection to the outside aerial and to rely instead on a set top aerial. Calculations indicate that a substantial increase in transmitter power would be required (of the order of $\sim$ 30 dB) if broadcasters were expected to provide a satisfactory service to television sets with set top aerials.

3.6 Example: Crystal Palace, London

Four of the existing analog transmitters at Crystal Palace each have an e.r.p. of 1,000 kW. The first four digital multiplex transmitters will each have an e.r.p. of 6.5 kW whereas the fifth and sixth multiplexes will be restricted to 1 kW in order to reduce potential interference on UHF channels 29 and 34 in the direction of northern France. The existing analog and proposed digital channel assignments are shown in Tables 4 and 5 below.

Table 4. Existing analog power assignments

UHF Channel	23	26	30	33	37
Power (kW)	1,000	1,000	1,000	1,000	250

Table 5. Proposed digital power assignments

UHF Channel	22	25	28	29	32	34
Power (kW)	6.5	6.5	6.5	1.0	6.5	1.0

There are many technical and/or commercial marketing issues still to be resolved. Not least is whether the multiplex should run at 12, 18 or 24 Mb/s. The higher the speed, the higher the required C/N at the receiver. In the more prosperous South East of England there are severe interference limits on transmitter power. This has an immediate impact on the speed of the multiplex and/or the size of the population served. This can be seen in Table 6 below.

Table 6. Predicted London population coverage (millions) using a) cut–off method and b) proportional method

Required min C/N (dB)	Best (of 6) Multiplex		Worst (of 6) Multiplex	
	a)	b)	a)	b)
12.0	11.1	11.8	5.5	6.9
16.5	10.2	11.0	4.0	5.9
20.0	9.4	10.2	2.8	4.9

The current commercial position is that in 1996 the UK government sought bids from the commercial sector and, in 1997, has assigned the six digital multiplexes as follows:

- The BBC have been given the best multiplex.
- The existing commercial broadcasters have been given the second best multiplex.
- The new Channel–5 and a Welsh regional broadcaster have been given the third best multiplex.
- The remaining three multiplexes were auctioned in the marketplace. A consortium of existing commercial broadcasters was awarded the franchise once it was agreed that BSkyB would be compensated for withdrawing from the consortium.

3.7 Regional coverage

Although 12 million of the 57.5 million people in the UK can be reached from one transmitter site at Crystal Palace in south London it requires many more transmitters to reach the population in the remainder of the country. 300km to the west of London lies the mountainous principality of Wales with

a population of just under 3 million. Diana, Princess of Wales, is perhaps their best known non–resident.

Wales is currently served by 6 principal transmitters and 187 additional repeater stations. Because the UHF frequencies are re–used many times over by the analog repeater stations it is no surprise that suitable taboo frequencies for digital television can be found for only three of the 187 repeater sites. Viewers who currently tune to the remaining 184 repeaters will not be able to enjoy digital television for many years to come.

If digital television is a failure this will not matter. If digital television is successful then it is planned to discontinue the analog television service in about 2007. It will take time before some of the freed analog frequencies can be reused for digital television broadcasting. In the meantime rural communities in Wales and other parts of the UK will have a restricted choice of television service compared to urban dwellers. Such an outcome runs contrary to the current UK environmental policy of providing similar telecommunications services to both urban and rural areas. The early deployment of a microwave video distribution service (MVDS) may provide a solution to this issue.

4. MVDS in the UK

4.1 Analog MVDS

In 1993 the Radiocommunications Agency (RA) who are part of the UK Department of Trade and Industry issued a performance specification (MPT 1550) for an analog MVDS service in the frequency band 40.5 – 42.5 GHz. The output power of the FM transmitter was limited to 200 mW per channel and the FM deviation to 26 MHz. Channel spacing was set at 29.5 MHz. The gain of an omnidirectional transmit aerial was limited to 8 dB, an aerial with a 64° beamwidth to 15 dB.

The receiver system assumed a gross noise figure (including losses) of 11 dB and an aerial gain of 32 dB. The 40 GHz MVDS band was divided into 128 horizontal and vertically polarised channels, each capable of carrying a PAL or D2–MAC television signal.

The RA also negotiated with other government administrations to harmonize the use of the 40 GHz band across Europe.

But the marketplace had changed. D2–MAC was yesterday's technology, the new interest was digital television.

4.2 Digital MVDS

In June 1996, after extensive consultation, the Agency issued Version 1 of MPT 1560, the Performance Specification for digital MVDS transmitters in the same 40 GHz band. Channel spacing was increased to 39 MHz (channel width to 33 MHz) thus accommodating 96 digital multiplexed channels in the 2 GHz wide MVDS frequency allocation. Modulation is QPSK and the digital television baseband signal is MPEG 2 and DVB/S compliant. The IF output frequency range of the receiver downconverter was increased slightly to cover the band 0.95 – 2.15 GHz.

Much of the RA 40 GHz MVDS specification is a brilliant reissue of the European DVB/S specification for satellite digital television. The only principal difference is that UK terrestrial MVDS will operate at 40 GHz whereas satellite transmissions can be found in the 11 or 12 GHz bands. The RA rationale is delightfully simple. If the viewer has already purchased a satellite digital television set top decoder he may easily add digital terrestrial MVDS for the relatively low cost of an integrated 15 cm horn aerial and Low noise Block (LNB) 40 GHz downconverter. The 1–2 GHz output of the 40 GHz downconverter will appear to be exactly the same as that of the 11–12 GHz satellite LNB. Such technical compatibility should allow a standard set–top box to provide both satellite and MVDS television programming. The new digital MVDS specification has aroused a considerable degree of interest. The results of the UK propagation studies at 40 GHz are reported elsewhere at this conference.

5. Summary

UK digital television will live or die by the specification of the set top box. The DVB/S protocol, used for satellite and MVDS, is based on high speed (24 Mb/s net speed) QPSK modulation of a single carrier. Digital terrestrial television is quite different: it is based on 16 or 64 QAM modulation of thousands of OFDM carriers. The crucial question, yet unanswered, is whether a satellite or terrestrial broadcaster, who will need to kick start the market with cheap set top boxes, will be willing to pay for the inclusion of the technology used by his rival.

REFERENCES

1. Digital Programme Services Licences: *Notes for the guidance of Licence Applicants.* Independent Television Commission, London, 1996.
2. B. T. Evans: *Some experiences in the realization of MMDS system.* Telsiks'97 Conference, Niš, 1997.

3. B. T. Evans: *Understanding Digital TV, the Route to HDTV.* IEEE Press, Piscataway, NJ, 1995.
4. ITC Guidance Note on Picture Quality in Digital Television: *Independent Television Commission.* London, May 1996.
5. ITC Note for Applicants on Coverage for Digital Television: *Independent Television Commission.* May 1996.
6. ITC Note for Applicants on Transmission Standards for Digital Terrestrial Television Broadcasting: *Independent Television Commission.* London, May 1996.
7. MPT 1560: *Performance Specification for Digital Multipoint Video Distribution Systems (MVDS) transmitters and transmit Antennas Operating in the Frequency Band 40.5–42.5 GHz.* UK Radiocommunications Agency, London, June 1996.
8. pr ETS 300 744 (DVB–TM 1545): *Specification for Digital terrestrial television.* ETSI, March 1996.
9. Television Transmitting Stations: *BBC Engineering Information.* London, 1997.
10. The Digital Specification on Transmission Standards: *Independent Television Commission.* London, 1997.