mm-WAVE DIRECT-TO-HOME MULTICHANNEL TV DELIVERY SYSTEM

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ABSTRACT

Millimetre-wave Multichannel Multipoint Video Distribution Service, known as M^3VDS, is a new means of delivering multichannel TV to the home. This contribution describes the concept, outlines the technology, and reports on the Demonstrator system operating at Saxmundham in England. Distribution by mm-waves has the potential to male a substantial impact on the TV market in some countries. Also it could be one of the first high-volume civil applications for GaAs monolithic circuits at mm-waves.

THE CONCEPT

The configuration of this new system is illustrated in Fig 1. Analogous to a cable TV system, there is a head-end at which a variety of programmes is assembled. The mix of 15 - 25 programme channels is drawn from many sources, which may include :-

* satellites, both low power and direct broadcast, at several orbit positions and frequencies
* taped programmes
* terrestrial UHF broadcast channels
* feeds from nearby cable systems
* local/regional programmes
* high-definition TV (HDTV) when available

The channels are first processed into a common format, for example PAL or a variant of the MAC family. They are then transmitted at frequencies in the 30 to 45 GHz mm-wave range from a local high-point chosen for best line-of-sight visibility throughout the service area. Due to the limitations of mm-wave propagation and line-of-sight considerations, the system coverage is of the order 10 sq.km. Each home receiving the service is equipped with a compact, 6-inch diameter, outdoor antenna/downconverter unit, and an indoor IF/demodulator for individual channel selection, as shown in Fig 2.

SYSTEM DESIGN

The most basic parameters controlling system design are transmitter power, receiver noise figure, and modulation type. Design margins are less generous than at lower frequencies. Solid-state mm-wave sources limit transmitted power to the order of 100mW per channel, whilst a receiver overall noise figure of 12dB is readily achievable where low cost is a prime consideration. This leads to the choice of frequency modulation, which enables adequate video signal-to-noise ratio to be maintained, despite the limited mm-wave power available. Furthermore it is common to satellite broadcasting, allowing the same volume-produced IF/demodulator units to be used.

Another basic parameter is the spacing between adjacent RF carriers. On the one hand it must be narrow to achieve efficient use of spectrum, whilst on the other it must not place such stringent requirements on the receiver local oscillators that they become uneconomic. A spacing of 38 MHz is compatible both with satellite channel plans and with the stability achievable from low-cost local oscillators controlled by dielectric resonators. To make the service attractive to viewers, 20 or more RF channels must be handled. Combining these by RF multiplexing would introduce substantial losses. Furthermore, amplification of a 20-channel block would require substantial backoff to avoid intermodulation, and the tens of watts then required could not be provided economically. To sidestep these problems, direct RF modulation is adopted, in conjunction with an individual antenna for each transmit channel.

Very heavy rainfall attenuates the signal, this fading determining the operating range. Knowledge of rainfall rate statistics, and their frequency dependent relationship to

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attenuation, allows derivation of the margin required to guarantee a specified grade of service. The chosen target is to deliver pictures of quality meeting CCIR grade 4 or better for 99.9% of the time. With a transmitted power of 100mW per channel, and a receiver noise figure of 12dB, UK rainfall statistics then permit a maximum range of about 3.3km for TV signals of conventional bandwidth.

THE SAXMUNDHAM DEMONSTRATOR

A prototype "Demonstrator" system has been established at Saxmundham in eastern England, to serve three purposes. Firstly it is exposing this new concept to system operators, the regulatory authorities, and manufacturers. Secondly it is providing a vehicle to explore the practicalities of system installation and operation. Line-of-sight penetration is an important consideration, and can approach 80 percent of homes. The extension of coverage to serve dwellings shielded by trees or tall buildings is being explored via MATV (Master Antenna TV) installations, together with the possibility of re-broadcasting in local pockets where the direct path is obscured. Lastly the Demonstrator is providing a testbed for the GaAs integrated circuit technology being developed for use in the receivers.

Signal Handling at the Head-End

At the head-end channels are received from both the Intelsat VA and Eutelsat 1 satellites, and from Regional transmitters of the UK terrestrial UHF broadcasting service. The channels arrive in a variety of formats and are first processed to achieve commonality. Conditional access decoding is carried out as necessary, and the sound subcarriers are then re-inserted at a common spacing to give the standard PAL I format. Autolevelling and pre-emphasis are then effected before the video signals are applied to the transmitters. At any one time a selection of eight of the channels is then re-radiated at around 28 GHz, frequencies chosen for the Demonstrator because they are in a band allocated for British Telecom use. If systems are to operate without mutual interference throughout the country, several blocks of frequencies will be needed. It is anticipated that production systems would operate mainly around 39 GHz, where sufficient spectrum could be made available.

The Transmitters

The transmitter sources are temperature-stabilised Gunn oscillators, frequency modulated by a varactor in the cavity. The thermal control uses heat pipes with electronically variable conductance so as to minimise temperature rise and ensure long-term reliability. The antennas are wide-angle waveguide horns. They illuminate a broad coverage zone from a point on its periphery, thereby being less susceptible to nearby obstructions than are centrally sited omni-directional antennas. Use of a dedicated RF oscillator and antenna per channel has proved to be a very simple and cost-effective configuration. At Saxmundham two standard 2-inch poles carry the eight transmitters, one of which is shown in Fig 3, in which the horn radiator can be seen.

The Receivers

The receiver employs an offset reflector antenna fabricated by a low-cost one-shot forming process. Attached directly to the antenna is the downconverter with an integral feedhorn to eliminate any interconnecting waveguide losses. Fig 4 shows the complete outdoor unit. The downconverter effects a frequency change to the 950-1750 MHz IF band. It employs GaAs MMWICs - Monolithic Millimetre-Wave Integrated Circuits to achieve low cost and reproducibility. Prototype downconverters installed at Saxmundham are a mix of hybrid and monolithic technology, including chips fabricated at BTRL and at a foundry in the USA. These downconverters are fully described in a companion paper (1). Development In the ensuing months will replace the present multi-chip assembly with a fully integrated one-chip or two-chip implementation ready for downstreaming to volume production, which could commence within two years or so. The use of MMWIC technology is the key to an affordable product, which demands an antenna/downconverter assembly at around $200 if M^3VDS is to take its place alongside satellite TV.

MARKETS

Growth of the TV market has been slowed in the UK by the high up-front cost of laying cable. Coaxial or optical fibre cable systems offer the interactive capability which ultimately will lead to them becoming universal. But at present they are not much in evidence outside the large urban centres with populations of 100,000 or more. Over 11 million UK homes are unlikely to be reached by cable systems this century. Now that development of the receiver chip-set is well under way, M^3VDS has the potential to bring multichannel TV to many of them much sooner. Excluding scattered rural communities, which are too sparse to be served economically, there is a UK market potential of some 8 million homes, principally in the demographic "middle ground" towns of around 10,000 - 100,000 population, for which M^3VDS is ideally suited.

Until now, the regulatory background in the UK has been unfavourable to microwave distribution. But recently the Government published its plans to liberalise broadcasting in the '90s, including encouraging the use of mm-waves for TV distribution. It plans to

award franchises permitting local delivery by this means, starting in 1991. The allocation of spectrum above 30 GHz to specific services is receiving active attention. Thus the potential exists for M^{3}VDS to expand the TV market rapidly, a development which could spread to other countries too. This presents a market opportunity for both franchise operators and the microwave industry, for whom M^{3}VDS may prove to be of prime significance as one of the first high-volume civil applications for MMWIC technology.

BENEFITS OF THE SYSTEM

M^{3}VDS offers the channel capacity of cable TV, but with the installation flexibility of satellite reception. Its compact receiving antenna offers home viewers a single entry point for programmes from all sources. They can view channels from different satellites without a steerable antenna, and viewers with more than one TV set can do so simultaneously without extra antennas. In the UK permission to install more than one satellite antenna must be sought from the town planning authorities. With the growing environmentalist lobby in Europe, the small antenna size and single-entry features are attractive.

M^{3}VDS is attractive to service operators too. It provides instant coverage throughout the service area as soon as the head-end is operational, and is cheaper to install than cable. Furthermore, underground cable installation work can often be disruptive and unpopular in the community.

Finally, M^{3}VDS should be attractive to the programme providers. Being quick and economic to install, it can rapidly expand the viewer base. This growth can help finance more new program making, making the product more attractive to viewers, and benefitting the multichannel TV industry as a whole.

CONCLUSIONS

M^{3}VDS is a new concept in TV delivery. To the home viewer it offers programmes from all sources via a single entry point, its compact unobtrusive antenna being environmentally attractive in comparison with alternatives. For the system operator its start-up costs are low compared with cable, and its potential to rapidly expand audiences will benefit the TV industry as a whole. With the maturation of MMWIC technology, the key to its economic viability, it should have a bright future.

ACKNOWLEDGEMENT

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REFERENCE

(1) P G Wilson and B C Barnes, "Millimetre-wave downconverter using monolithic technology for high volume application", IEEE MTT-S 1989 International Microwave Symposium Digest.

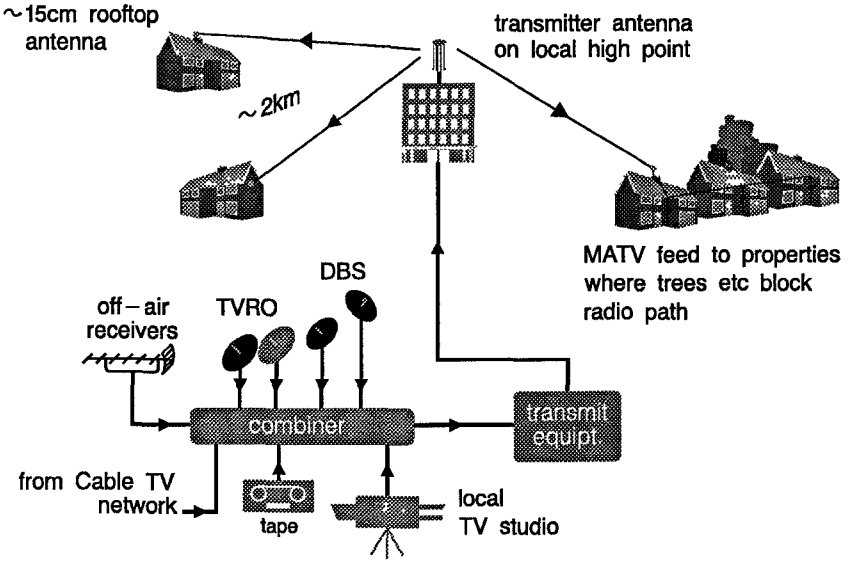

Fig 1 M^{3}VDS CONCEPT

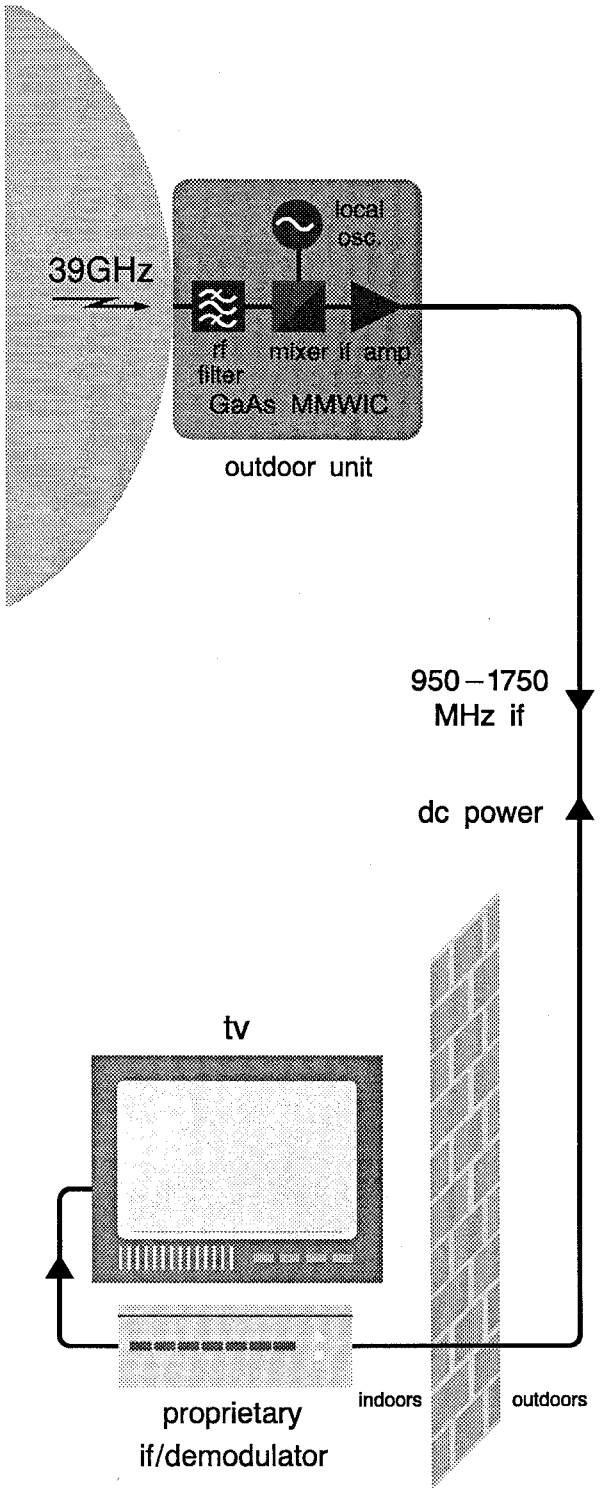

Fig 2 HOME INSTALLATION SCHEMATIC

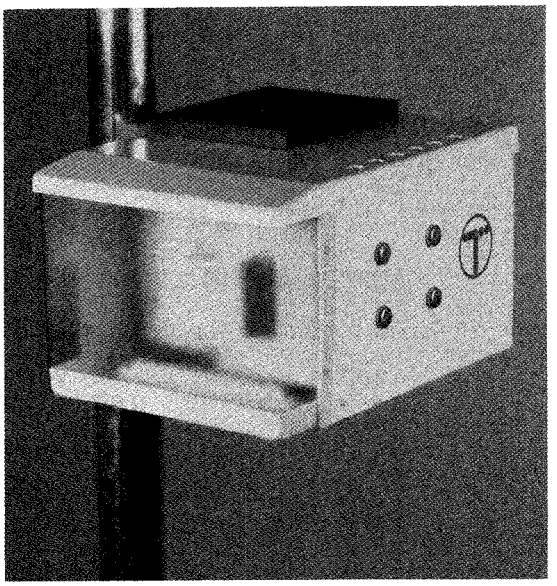

Fig 3 SINGLE-CHANNEL TRANSMITTER

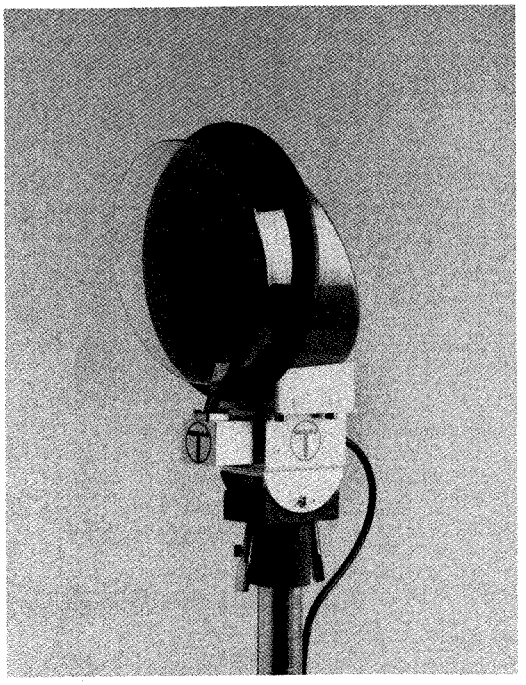

Fig 4 RECEIVER OUTDOOR UNIT