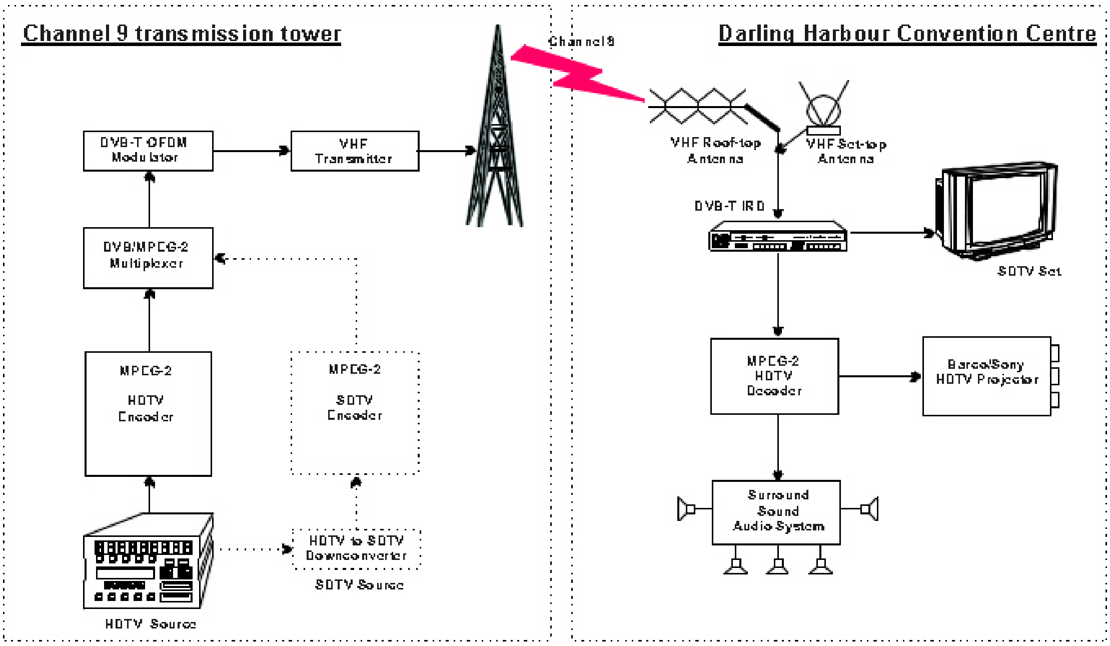
DVB AND HDTV



DVB shows Australia "off-the-shelf" HDTV	FACTS Engineering Meeting Sydney 2-3 December '97	DVB Digital Video Broadcasting

On the 2nd and 3rd of December in Sydney, DVB demonstrated its revolutionary COFDM "orthogonal" digital terrestrial TV transmission system, DVB-T, and its capacity to carry High Definition TV. The following article is a digest of a paper on DVB and HDTV written for the IBC'97 conferences by Ken McCann and Charlie Sandbank. McCann is the Chairman of the DVB MPEG-2 Implementation Guidelines Group, also known informally as "the Ken McCann group". Co-author Charlie Sandbank works for the UK's Department of Trade and Industry. Ken McCann works for NTL (National Transcommunications Ltd).

Introduction

The progression towards High Definition Television (HDTV) has been given regular consideration during the last four years as the DVB specifications were taking shape. Despite the fact that European Broadcasters in general gave the commercial requirements for HDTV a low priority, the need for '"future proofing" has been borne carefully in mind at the various stages of the development of the DVB systems.

The challenge has been to provide the growth potential whilst maintaining the excellent properties of the DVB system without introducing complexity which might prejudice the successful introduction of Digital Television.

This paper describes the options proposed by DVB and explains the rationale for the choice.

Compatible Progression to HDTV

One of the attractions of Digital Broadcasting is the flexibility it brings to the medium. This has been extensively exploited in the DVB system in which the "Data Container'" concept allows the broadcaster to allocate capacity to a variety of services depending on the requirements of the material and the tastes of the audience.

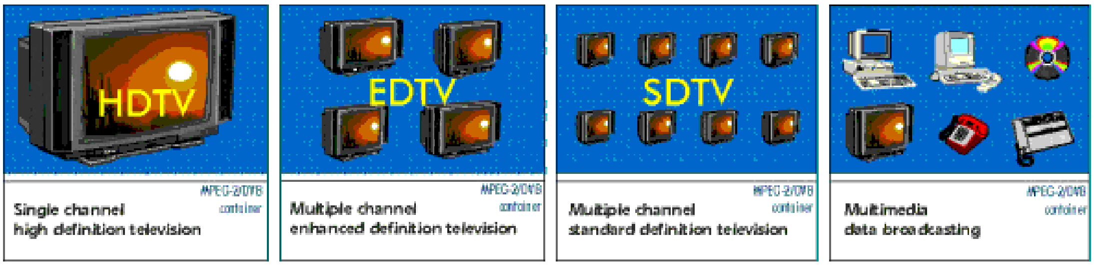


Figure 1 DVB / MPEG-2 Data Containers

DVB offers great flexibility in the use of data capacity for high picture quality, for more programmes at lesser quality or for new types of facilities such as interactive services. Allocations can even be made dynamically, so that the same transmission may offer HDTV services at one time of day and multiple channel SDTV services at another time of day.

In Europe, the short-term commercial prospects were recognised as being much more auspicious for large numbers of SDTV channels (and interactive services) than for HDTV. However, the commercial prospects for HDTV could change rapidly following a major breakthrough in domestic display technology. Such a breakthrough has traditionally been predicted to be about 5 years away for the past 20 years, but this prediction now finally appears to be approaching reality.

Will DVB SDTV receivers "go dark" when receiving HDTV?

The short answer is "No". Not if the broadcaster uses the Simulcasting approach to broadcast "downconverted HDTV" programme in SDTV format in the reserve bandwidth alongside the main HDTV programme.

Several future-proof scenarios have been envisaged for the introduction of HDTV services. One of these assumed that homes prepared to purchase top-of-the-range terrestrial HDTV equipment would also purchase new, efficient roof-top antennae to enable the reliable reception of HDTV. In addition, it was considered that there would be a second population of viewers who would wish to watch SDTV pictures on portable receivers.

Thus the transmitted signal would need to have two components - a highly rugged SDTV bitstream of limited bit-rate and a less rugged but higher bit-rate HDTV bitstream. Both elements in the signal could be adjusted on a dynamic basis in terms of user-adjustable COFDM broadcast parameters (*See **DVB-T and the Magic of COFDM***).

In tests carried out of this method, known as "hierarchichal coding", using the DVB-T terrestrial system, it was found that SDTV with a suitable ruggedness for portable reception needed a far greater share of the overall digital "bandwidth" than the HDTV. The analysis showed that the total channel capacity required for hierarchical coding was only fractionally less than that required for Simulcast transmissions.

A similar result was obtained for satellite transmission as part of the European RACE project HD-SAT, which aimed to provide graceful degradation from HDTV to SDTV under adverse propagation conditions.

In short, all the tests pointed to the conclusion that the most effective strategy to achieve HDTV compatibility with SDTV transmissions was to optimise the coding of the two video streams separately and to use Simulcasting.

Simulcasting provides the same coding efficiency, and allows reduced decoder complexity - which hits everyone's bottom line in a good way. It also gives the broadcaster the flexibility to select different source material for his HDTV and SDTV audience.

Simulcasting can allow the SDTV data stream to have increased ruggedness for applications such as portable (and possibly mobile) reception, whilst the HDTV data stream can be optimised for fixed reception by sophisticated top-of-the-range receivers.

MPEG Profiles and Levels

The MPEG-2 video coding standard was deliberately conceived as a generic, or application-independent solution. The goal was to achieve economies of scale and encourage inter-working across as wide a range of different delivery mechanisms and quality requirements as possible.

MPEG-2 video is a family of systems, each having an arranged degree of commonality and compatibility. It allows four source formats, or ‘Levels’, to be coded, ranging from Limited Definition (about today’s VCR quality), to full HDTV - each with a range of bit rates.

In addition to this flexibility in source formats, MPEG-2 allows different ‘Profiles’. Each Profile offers a collection of compression tools that together make up the coding system. A different Profile means that a different set of compression tools is available.

For practical considerations of decoder cost and complexity, the MPEG-2 video standard defines a limited number of subsets of the standard which specify conformance points by means of profiles and levels (See Figure 2).

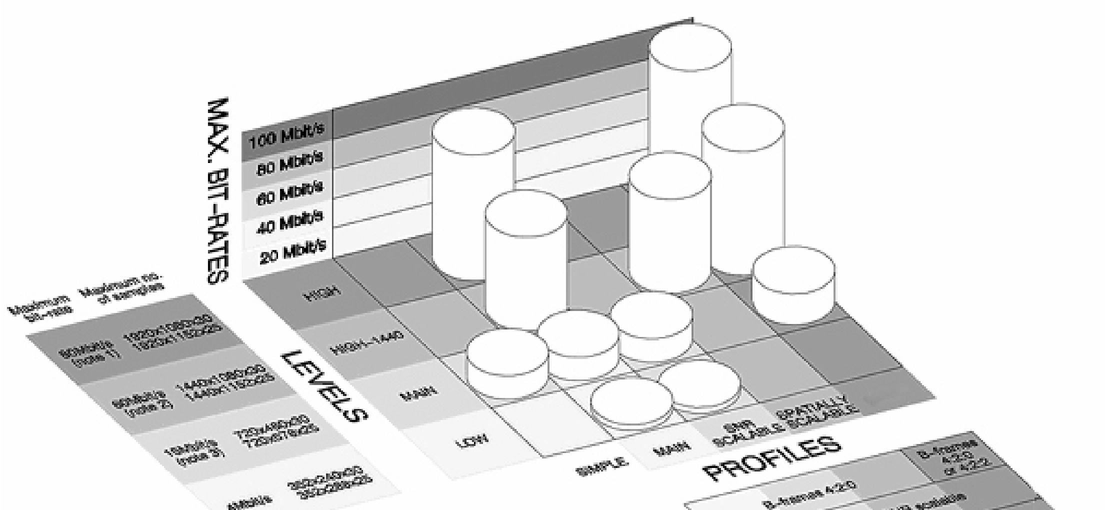


Figure 2 MPEG-2 Conformance Points

For example, a *Main Profile* bitstream may have up to 720 pixels per line *at Main Level* but may have up to 1920 pixels per line at *High Level*.

The simulcast approach of the DVB system has enabled the complexity of the SDTV decoder to be limited to that which is required for MPEG-2 Main Profile at Main Level (MP@ML), whilst an HDTV receiver must be capable of decoding a Main Profile at High Level (MP@HL) bitstream.

In a simulcast SDTV+HDTV transmission, an SDTV receiver would decode the MP@ML video stream from the Transport Stream whilst an HDTV receiver would decode the MP@HL signal. The simulcast components do not necessarily have to be in the same Transport Stream but the DVB system provides the flexibility to allow a single Transport Stream to contain programme material intended for different types of receivers.

Up-conversion

With the expected explosion in the number of TV channels due to the lower cost and increased capacity offered by digital broadcasting, there should be no difficulty in accommodating the additional data rates for HDTV MP@HL, including the associated compatible SDTV MP@ML stream. However there is another option for progressing to HDTV based on the transmission of only an MP@ML stream involving an SD-to-HD "up-converter" incorporated in receivers.

Why? There may be broadcasters who are unable to increase the data capacity per programme beyond around 6Mbit/s but who wish to deliver HDTV source material to suitably equipped receivers with higher than SDTV quality. Significant improvement is possible by sub-sampling the HDTV source to convert it for transmission as MP@ML and subsequent suitable up-conversion in the receiver. Such transmissions would of course be decoded as SDTV in the baseline DVB receiver.

This mode of operation is also attractive to broadcasters who are prepared to allocate a higher data rate to the signal in the interest of improved picture quality, but not to the extent of simulcasting. If the MP@ML video is transmitted at a data rate near to the 15Mbit/s upper limit of MP@ML, then the quality of the up-converted picture can be close to that of the HDTV source before down-conversion.

DVB Guidelines for HDTV

The ETSI document **ETR 154** specifies the DVB guidelines for the implementation of the MPEG-2 system layer, video compression and audio compression for satellite, cable and terrestrial broadcasting applications. The recent Revision 2 of this document has extended its scope to encompass HDTV and SDTV applications for both 25Hz and 30Hz video frame rates.

The guidelines for the Integrated Receiver-Decoder (IRD) in ETR 154 represent a minimum functionality that all IRDs of a particular class are required to either meet or exceed. The rules of operation for the encoders are features and constraints, to which the encoding system should adhere in order to ensure that the transmissions can be correctly decoded.

IRDs and bitstreams are classified as:

“25Hz” or “30Hz”, depending on which nominal video frame rate is supported. It is expected that 25Hz IRDs will be used in those countries where the existing analogue TV transmissions use 25Hz frame rate and 30Hz IRDs will be used in countries where the analogue TV transmissions use 30Hz frame rate. There are also likely to be “dual-standard” IRDs which have the capabilities of both 25Hz and 30Hz IRDs.

“SDTV” or “HDTV”, depending on whether or not they are limited to pictures of conventional TV resolution. The capabilities of an SDTV IRD are a sub-set of those of an HDTV IRD so that all HDTV IRDs must be capable of decoding SDTV bitstreams of the same frame rate as shown in Table 1 below.

Video Stream	25Hz SDTV IRD	25Hz HDTV IRD	30Hz SDTV IRD	30Hz HDTV IRD
25Hz SDTV bitstream	✓	✓		
25Hz HDTV bitstream		✓		
30Hz SDTV bitstream			✓	✓
30Hz HDTV bitstream				✓

Table 1 - Minimum IRD Capability

It should be kept in mind that Table 1 relates to video bitstreams, not to MPEG-2 Transport Streams. A significant feature of the DVB system is that a single Transport Stream may contain programme material intended for more than one type of IRD, typically when simulcasting SDTV and HDTV video streams. In this case an SDTV IRD will decode and display SDTV pictures whilst an HDTV IRD will decode and display HDTV pictures from the same Transport Stream, as summarised in Table 2 below.

Simulcast Video Stream	25Hz SDTV IRD	25Hz HDTV IRD	30Hz SDTV IRD	30Hz HDTV IRD
25Hz (SDTV +HDTV)	✓	✓		
30Hz (SDTV +HDTV)			✓	✓

Table 2 - IRD Reception of Simulcast Video

Image (Scanning) Formats

DVB SDTV bitstreams must comply with the restrictions of MPEG-2 Main Profile at Main Level, which sets upper limits of:

- 576 lines per frame,
- 720 luminance samples per line,
- 10,368,000 luminance samples per second.

These parameters correspond to ITU-R 601-D1.

DVB HDTV bitstreams should be able to deliver all allowed formats within the constraint of Main Profile at High Level, which sets upper limits of:

- 1152 lines per frame,
- 1920 luminance samples per line,
- 62,668,800 luminance samples per second.

However, in line with the of the recent decisions by the ITU and DAVIC to endorse the Common Image Format (CIF), the single recommended source format for both 25Hz and 30Hz frame rates is:

- 1080 lines per frame,

- 1920 luminance samples per line.

Digital TV - another standards gulf?

With the universal adoption of the MPEG-2 standard for Digital TV Broadcasting we have moved closer than in the analogue domain towards a worldwide TV standard. Most of the SDTV formats are still related to the analogue active line rasters and the 25/30Hz frame rate legacy of the Victorian Power Engineers remains firmly with us. That is why these various formats have been included in DVB/MPEG-2, which is finding favour in many countries throughout the world.

Although nothing can be done about the 25/30Hz legacy, HDTV provides yet another opportunity to move towards a world-wide TV standard. The HDTV Common Image Format of 1080 lines and 1920 pixels per line recommended by the ITU and DAVIC and endorsed by DVB enables the advantages of economies of scale to be realised at the source and display ends of the broadcast chain.

Conclusions

The DVB system provides a range of options for progressing towards HDTV as the various markets throughout the world develop. DVB HDTV can be efficiently introduced in a way which does not disadvantage the owners of standard definition receivers or prejudice the rapid and successful implementation of Digital TV.