CHAPTER CONTENTS

_____ Notes _____

Appendix 2 - HDTV

http://www.hdtv.net/hdlinks.htm

http://www.atsc.org/

The following information was obtained from IEEE Spectrum March 1999.

DTV

DTV overseas

Terrestrial and satellite DTV is available in many parts of the world. In the US, the DTV resolution is the same as standard definition [SD] format. In the UK, DVB supports high-definition television with 1250 lines. The DVB standard adopted in Europe also has double the number of pixels per line.

Australia has also opted for the European HD-DVB system

Although terrestrial DTV has yet to begin elsewhere in Europe at this writing, the DVB standard is in place and ready to compete with current digital satellite service. The economic models for the continent are not yet clear, but the UK's is an interesting example. Viewers there have a choice between free-to-air and subscription-based terrestrial DTV. As an incentive to the latter, the pay-TV services subsidize the cost of the receiving hardware, offering it for about half the $600 price of a typical set-top box.

Japan already has settled on an HDTV system comparable to the U.S. 1080-line interlaced format, but using a coded orthogonal frequency-division multiplexing (COFDM) modulation scheme similar to Europe's DVB. Japanese broadcasters and manufacturers prefer that system, as it is more robust for mobile applications, including automotive and hand-held receivers.

So all eyes are on China now, and the lobbying is fierce for that huge market, where the ATSC contingent will demonstrate the system in conjunction with domestic TV giant Konka this fall. --S.A.B.

DTV formats

There are 18 picture formats in the ATSC but only four relate to home viewers. These comprise two HD[†] and two SD[†] displays, where the picture is either progressively scanned [p] or interlaced [i]. Eventually, another HD format, 1080p, will be developed.

[†] High Definition

[†] Standard Definition

The chief ATSC television formats

Format	Name	Screen	Scan type	Resolution, pixels	Bit-rate, Mb/s at 60/30/24 frames per second[a]
HDTV	1080p	16:9	Progressive	1920x1080 (2 073 600)	[b] /N.A. / N.A.
HDTV	1080i	16:9	Interlaced	1920x1080 (2 073 600)	N.A./995/796
HDTV	720p	16:9	Progressive	1280x720 (921 600)	885/442/334
SDTV	480p	16:9	Progressive	704x480 (337 920)	324/162/130
SDTV	480p	4:3	Progressive	640x480 (307 200)	295/148/118

[a] Megabits before compression for transmission.
[b] Not yet determined.
N.A. = not applicable to format p = progressively scanned i = interlaced

In the resolution column of the table, the first figure gives the number of horizontal pixels per line, and the second the number of TV scanning lines. The figure in parentheses indicates total pixels transmitted per frame. Bit-rate indicates the millions of bits per second needed for a picture comprising 60, 30, or 24 frames per second--before compression is applied to transmit it.

The NTSC system transmits 30 frames per second as 60 interlaced, alternating fields. HDTV 1080i does the same, though with greater vertical resolution (1080 vs. 540 lines). But HDTV 720p and the SDTV formats transmit 30 frames progressively, drawing the entire frame in a single scan. It's envisioned that DTV formats will some day carry double the amount of vertical information, providing 60 frames per second progressively scanned. The 24-frame rate applies to programming originally produced on movie film, with its inherently higher resolution, as opposed to video- or PC-generated material.

There are 5 principle ATSC television formats in the US.

Format	Name	Aspect Ratio	Scan	Resolution	Bit Rate, Mbps at 60/30/24 frames/sec
HDTV	1080p	16:9	Progressive	1920x1080	
HDTV	1080i	16:9	Interlaced	1920x1080	NA/995/796
HDTV	720p	16:9	Progressive	1280x720	885/442/334
SDTV	480p	16:9	Progressive	704x480	324/162/130
SDTV	480p	4:3	Progressive	640x480	295/148/118

DTV for the PC

The first low-priced DTVs will be PC based since they have the computational power and progressive scanning. Several companies have announced the approaching availability of DTV decoder cards for PCs. Some of these decoders also include a TV tuner to receive the broadcasts, although others would require an add-in TV tuner card.

Among those announcing DTV products for the PC are Panasonic (Matsushita Electric Corp., Osaka) and Compaq Computer Corp., Houston, Texas, which jointly developed a DTV tuner-decoder board that they will make available to all PC manufacturers. Zenith Corp., Glenview, Ill., in conjunction with partner SkyStream Corp., Mountain View, Calif., has demonstrated a PC card that handles DTV datacasts as well as video entertainment from either broadcast or cable sources. Separately, Zenith's corporate parent--Korea's LG Electronics--has demonstrated its own chipset decoding signals for SDTV monitors. Royal Philips Electronics NV, Amsterdam, the Netherlands, also has announced the availability of a DTV “reference” board, this one for installation in the PCI slot of PCs. That board has the backing of microprocessor giant Intel Corp., as it leverages the computational power of the Intel Pentium II processor in the PC.

Not to be left out, Tokyo's Hitachi Ltd. has said that its all-format decoder, first announced in 1995, will be embedded on chips jointly designed with Equator Technologies Inc., of Campbell, Calif. The chip's key application would be to downconvert HDTV formats for viewing on SDTV monitors.

DTV compression and scaling

MPEG-2 data compression reduces the enormous transmission bit rates to a manageable size.

If a single frame of 1080-line interlaced DTV contains 2 million pixels, and there are 30 frames in each second of video, the uncompressed data rate is 995 Mbps. Because the maximum data transfer rate for the 6-MHz DTV channel is just 19.4 Mbps, the data must be compressed before transmission and decompressed at the DTV set.

Scaling- and image-shaping techniques are used to redraw a 2-megapixel image at the receiver. Unfortunately, current displays cannot handle this amount of data. Most so-called HD displays deliver 1 to 1.5 megapixels. 480-line progressive scan SD displays can only show a fifth of an incoming HD-1080i signal.

Digitally addressed liquid-crystal display, plasma, and other display technologies can handle HDTV resolution, but cost too much for consumers as yet.

The CRT spot size is governed by mechanical factors. Although shadow mask/aperture grille perforations could be made finer, picture brightness decreases. Brightness can be increased, but this causes the shadow mask to overheat and warp.

Thomson Consumer Electronics, specs its 38-inch widescreen direct-view set at 1 megapixel.

Metal masks are not an issue with projection sets, but lens-diameter size for the three (red, green, and blue) CRTs is. At present, 9-inch guns constitute the heavyweight artillery for DTV, although some manufacturers favor 7-inch batteries for reasons of reliability and practicality. Theoretically, a CRT lens can be of infinite size to yield a spot beam that is infinitesimal. But, in the real world, the set has to be light in shipping weight and able to pass through a door. Thomson's 61-inch ProScan HDTV rear projector throws 1.5 megapixels onscreen.

When a 2-megapixel 1080-line interlaced HDTV broadcast is displayed on a 1.5-megapixel HDTV set the image must be scaled. This is not the same as decimation.

ADTV

ADTV[1] is a term that can be used to denote one of many EDTV and HDTV proposals. Unfortunately, it is also used to denote a specific digital HDTV proposal put forward by the ATRC[†] formed by Thomson, Philips, NBC, Sarnoff Research and Compression Labs.

EDTV vs. HDTV

In this examination, the term EDTV will be applied to those systems with less than 1000 lines in the image, and HDTV will be used to describe those systems with more than 1000 lines.

Since the radio waves are strictly controlled by government regulations and international treaties, there is no possibility of increasing the bandwidth of existing TV broadcast transmitters to meet the demands of HDTV. Therefor, a great deal of effort is being spent on trying to compress HDTV into the standard channel bandwidth. In North America, this is sometimes called ‘NTSC compatible’ HDTV. It is in fact nothing of the sort.

Although most ADTV proposals can fit into the standard broadcast band, the signals broadcast are not backward compatible with present TV receivers. A regular receiver would require a converter to decode the signal and display part of the broadcast image. Specially designed ADTV receivers could display the entire image.

A2.1 EDTV

Enhanced definition TV has a wide screen with an aspect ratio of 16:9, and the same or nearly the same number of lines as conventional TV. Some of the proposals for EDTV include:

- MAC
- PALplus
- EDTV-2

These systems are somewhat backward compatible with the existing networks. If any of them do become adopted, they may have end up delaying the introduction of HDTV for quite some time. This may not be such a bad thing, because it may allow the industry to overcome in a cost-effective manner some of the technical issues that have yet to be resolved.

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1 *HDTV and Today’s Broadcasting World*, SMPTE Journal, January 1990

† Advanced Television Research Consortium

MAC

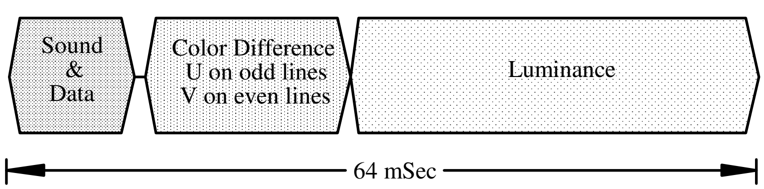
The MAC system is not backward compatible in the usual sense because it requires a special decoder. It is somewhat backward compatible in that it can be transmitted on conventional broadcast channels.

One of the “advantages” of the MAC system is that it allows EDTV to gradually evolve to HDTV.

The MAC† system was developed to take advantage of the 27 MHz channel allocated for DBS†. Versions A and B have since been dropped, but versions C, D, and E are still being pursued. The E version is HDTV.

System	Comments[2]
A–MAC	Data and sound were multiplexed onto a 7.16 MHz sub-carrier. No longer in use.
B–MAC	Requires a bandwidth of 6 MHz. Data is transmitted by using multi-level pulses. It is used by cable services in Canada and Australia, the American Forces broadcasting in Europe, and the UK betting information service. The equipment is built by Scientific Atlantic.
C–MAC	Frequency modulation is used with video segment and phase modulation for the audio and data. It supports an instantaneous data rate of 20.25 Mbps or a continuous data rate of 3 Mbps. It is used in Norway.
D–MAC	Used duo-binary encoding to reduce the required bandwidth. The entire D–MAC signal is frequency modulated on a carrier for transmission. It uses an instantaneous data rate of 20.25 Mbps and can support eight 15 KHz audio channels. The baseband video bandwidth is 8.5 MHz and occupies 10.5 MHz when transmitted using vestigial AM.
D2–MAC	This system is identical to D–MAC except that the data channel is limited to 10.125 Mbps. It occupies 7 MHz when transmitted using vestigial AM.

The MAC system employs time division multiplexing to reduce cross color effects. This increases the required bandwidth since some form of time compression must be used. The luminance signal is compresses by a factor of 1.5 while the chromance signal is compressed by a factor of 3. Also, the U color difference signal is broadcast on the odd numbered lines while the V signal is carried on the even lines.



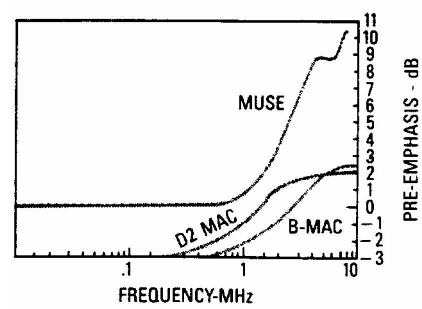
† Multiplexed Analog Components

† Direct Broadcast Satellites

2 *MAC Vision*, Electronics World + Wireless World, May 1990

Notes

MAC Pre-emphasis[3]



Most versions of MAC use progressive scanning rather than scan interlacing. In order to be compatible with wide screen formats, D–MAC has panning vectors built into the data stream to allow production of a conventional 4:3 picture or a wide screen 16:9 picture.

Although a video line is defined in terms of clock periods, the video information is broadcast in an analog form. It is digitized in the receiver and processed prior to being displayed.

C-MAC was optimized to fit into satellite transponder channels that are 27 MHz wide. This is acceptable for DBS applications, but does not work on cable distribution system, where the channel allocation is about 8 MHz.

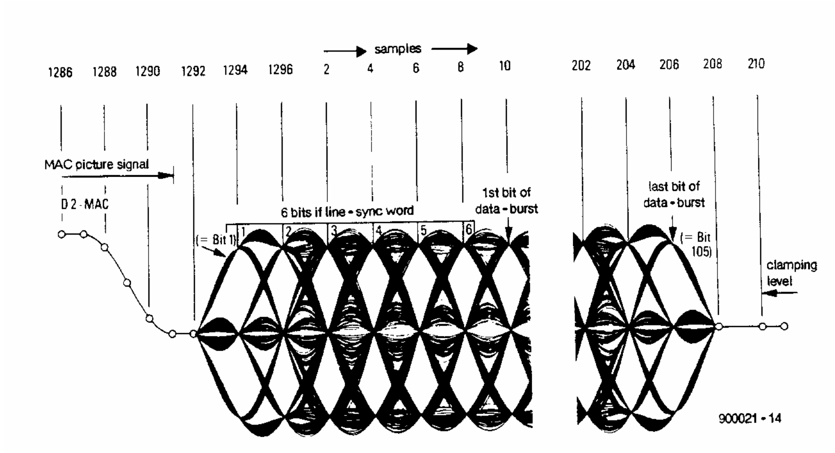
The D-MAC system was developed to meet the needs of the cable TV industry. By using duobinary[4] encoding and vestigial amplitude modulation of the analog component, the signal bandwidth can be reduced to 8.5 MHz. This is just outside of the require range. The D2-MAC system reduced the bandwidth even further to 5.3 MHz by cutting the data burst rate in half.

3 *High Definition Tele-Vision*, Radio Electronics, February 1989, FIG 9

4 *Introduction to Duobinary Encoding and Decoding*, Elektor Electronics, January 1990

Notes

MAC Waveform[5]

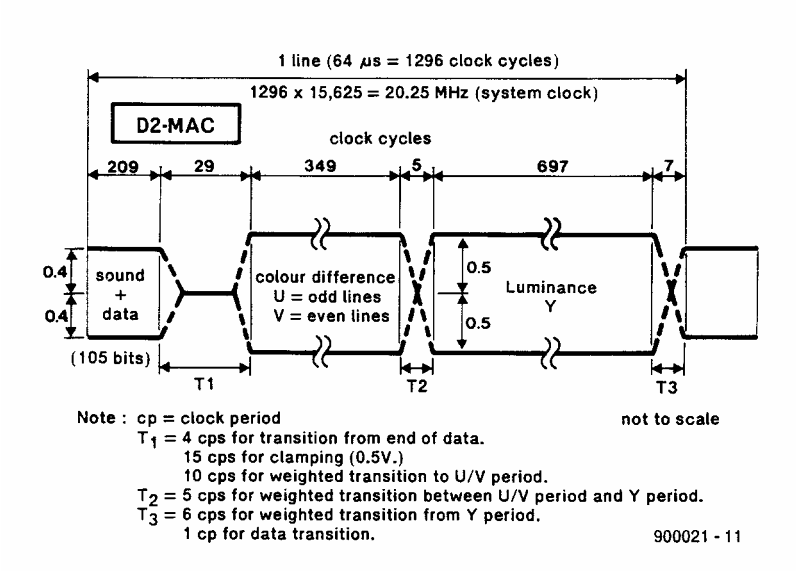


The D2-MAC data burst contains one of two 6 bit line synchronization words [001011 or 110100]. The data burst in line 625, which occurs at the end of a frame, is used to identify even and odd frames. On this line, the synchronization bits are followed by the hexadecimal pattern 55. This is followed by the hexadecimal pattern 65AEF3153F41C246 preceding even number frames, and its inverted form preceding odd numbered frames.

The sound & data channel is capable of carrying up to 8 audio channels or a host of data services in the C-MAC version whereas the D2-MAC system can support 4 channels. The 99 data bits of lines 1 - 623 consist of 82 packets of 751 bits each. The packet has a 23-bit header and 8-bit packet code to distinguish between the different sound, data services and features. One of the more useful features that can be supported is multi-language commentary.

5 *Introduction to Duobinary Encoding and Decoding*, Elektor Electronics, January 1990, FIG 4

D2-MAC Characteristics[6]



FM	13.5 MHz/V; pre-emphasis transition at 1.37 MHz, deviation ±300KHz
Lines/Picture	625
Data	Lines 1 to 625; 2 - 4 PSK; 106 bits per burst [6 sync bits, 99 data bits]; instantaneous bit rate 10.125 Mbps;
Video	Lines 24 - 310 and 336 - 622 *Y* in all lines; 697 samples/line; compression ratio 3:2 *U* in odd lines, *V* in even lines; 349 samples/line; compression ratio 3:1
Sampling Clock	20.25 MHz
Line 624	105 bits and analog reference signals
Line 625	648 bits [6 for H sync, 32 for clock run-in, 64 for V sync, 546 for service information]

This system can readily be scrambled by swapping the MAC components at predetermined cut points. These cut points can be encoded by using a 16-bit pseudo-random sequence generator. A second method of scrambling the signal is to add a pseudo-random bit sequence to the sound and data stream. In this way, an authorization key is needed to correctly receive the image. This allows carriers to implement pay per view features in a relatively simple and cost effective manner.

D2MAC is currently being used in some European pay per view cable systems.

6 *The MAC System*, Elektor Electronics, July/August 1987, FIG 2

PALplus

Applications Notes\Video\Pal Plus.pdf

PALplus, sponsored by several European broadcasters, has been in use since 1994. The objective was to develop an EDTV system compatible with existing receivers.

A PALplus picture has 574 active lines and a 16:9 aspect ratio. It appears as a letterbox image with 430 active lines on a conventional TV.

There are two versions: the B/G system occupies 5 MHz and the I system occupies 5.5 MHz. PAL encoding is used to minimize cross coupling between chromance and luminance.

Line 23, the Wide Screen Signaling (WSS) line, is used by most broadcasters to identify the signal format in use. This line distinguishes between the Film Mode and Camera Mode. In the film mode, both fields are derived from the same image. This allows the TV set to operate in the progressive scan mode.

Helper Signal

The extra information needed to restore full luminance vertical resolution is carried by a ‘helper’ signal coded into the letterbox black bars. It is a signal containing the differences between the original 574-line 16:9 ratio picture and the picture, which would be obtained by merely taking the 430-line letterbox 16:9 image and interpolating it into 574 lines.

Clean PAL coding eliminates the colored moiré pattern created when the camera scans certain textile patterns.

The EBU expects that a Ghost Cancellation Reference (GCR) signal will appear on line 318. This will allow the TV to measure any ghost signal and cancel it.

EDTV-2 [MUSE]

Narrow Muse

Narrow MUSE was developed for DBS applications. It has a baseband bandwidth of 8.1 MHz, which is compressed to 4.86 MHz and broadcast on a 6 MHz analog channel. It is therefore not ‘NTSC compatible’ and requires a low-cost converter to allow it to be viewed by a standard receiver.

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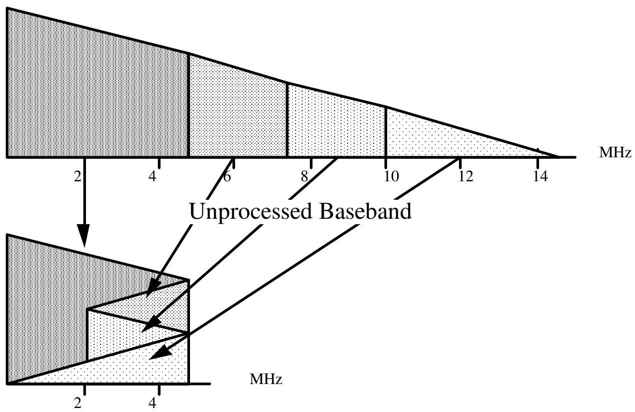


MUSE Compressed Baseband

The baseband signal contains 1125 scanning lines. This is reduced to 750 prior to broadcasting by the MUSE process. Field and frame-offset sub-sampling are used on stationary parts of the picture, but only line-offset sub-sampling is used on moving portions. The receiver uses interpolation to reproduce the original image.

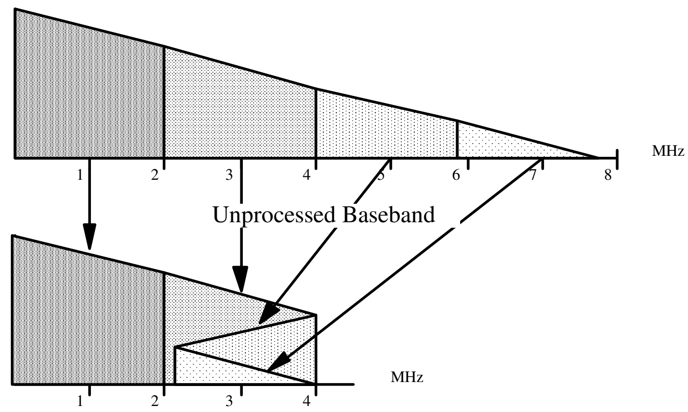
Narrow-MUSE Video	
Source Lines Per Frame	1125
Broadcast Lines Per Frame	750
Field Rate	60/sec
Aspect Ratio	16:9
RF Bandwidth	6 MHz
Baseband Bandwidth	4.86 MHz
Colorimetery	SMPTE 240M

Narrow-MUSE Audio	
Number of Channels	A Mode: 4 B Mode: 2
Signal Bandwidth	A Mode: 15 KHz B Mode: 20 KHz
Dynamic Range	A Mode: ≥ 90 dB B Mode: ≥ 96 dB
Coding Scheme	DPCM near instantaneous companding. A Mode: 8 ranges B Mode: 6 ranges
Modulation	Multiplexed during vertical blanking

MUSE-6

In order for a conventional receiver to view this signal, a decoder is required. The decoder allows the entire picture to be seen but top and bottom masking is used to preserve the aspect ratio. The conventional receiver displays only 345 lines, but an ADTV receiver would display the same image with about 690 lines.

The unprocessed bandwidth is about 7.7 MHz. This is compressed into the NTSC baseband by using two 2-frame offset sub-carriers to interleave the high frequency components into the 2 - 4 MHz region of the baseband.



Compressed Baseband

Since the standard TV receiver would display 345 lines, approximately 160 lines are left blank or masked. MUSE-6 uses the masked lines to cram in all of the additional video information that is needed by an ADTV receiver to display a 690-line image. The high frequency components associated with this additional information are folded over to fit into a standard NTSC channel.

MUSE-6 Video	
Source Lines Per Frame	1125
Broadcast Lines Per Frame	525
Field Rate	60/sec
Aspect Ratio	16:9
RF Bandwidth	NTSC
Baseband Bandwidth	4.2 MHz
Colorimetery	NTSC

MUSE-6 Audio	
Number of Channels	2
Signal Bandwidth	15 KHz
Dynamic Range	≥ 90 dB
Coding Scheme	DPCM near instantaneous companding, 8 ranges
Modulation	Multiplexed during horizontal blanking

MUSE-9

This system provides an additional 3 MHz augmentation channel to improve the resolution of moving images and provides a resolution twice that of the standard NTSC system. It also has 4 digital audio channels.

MUSE-9 Video	
Source Lines Per Frame	1125
Broadcast Lines Per Frame	525
Field Rate	60/sec
Aspect Ratio	16:9
RF Bandwidth	Main Channel: 4.2 MHz Augmentation Channel: 3 MHz
Baseband Bandwidth	Main Channel: 6 MHz Augmentation Channel: 2.1 MHz
Colorimetery	SMPTE 240M

MUSE-9 Audio	
Number of Channels	A Mode: 4 B Mode: 2
Signal Bandwidth	A Mode: 15 KHz B Mode: 20 KHz
Dynamic Range	A Mode: ≥ 90 dB B Mode: ≥ 96 dB
Coding Scheme	DPCM near instantaneous companding. A Mode: 8 ranges B Mode: 6 ranges
Modulation	Multiplexed during vertical blanking

A2.2 HDTV

High definition television has been in development for many years, but as yet, no one particular implementation has gained international acceptance and standardization. Although a Japanese version has been broadcast via satellite for several years, the rest of the world has been reluctant to adopt to adapt the system. Consequently, it is necessary to give a brief overview of a number of different proposals, the most of which are eventually headed for oblivion.

The basic objective of HDTV is to produce pictures with greater resolution and a wider picture screen than is currently available, something approaching 35mm quality.

Achieving these objectives is not easy, since it requires:

- New TV cameras and production equipment
- New wideband distribution systems
- New TV receivers

Consequently, there will probably be three different groups of standards developed to define the various HDTV environments:

- Production standards
- Satellite and fiber distribution standards
- Regular broadcast

Of these three, the last is proving to be the most difficult, since the HDTV signal needs to be dramatically reduced in bandwidth to fit in the current RF slots. In 1987 only the production standard SMPTE 240M, was adopted. The uncompressed luminance bandwidth for this system is 30 MHz. There are also two 15 MHz chromance signals.

SMPTE 240M Production Standard	
Aspect Ratio	19:9
Minimum Viewing Ratio	2.5 : 1
Signal Format	Component
Transmission Format	Digital
Scanning	2 : 1 Interlace
Scanning Lines	1125
Field Rate	60 fields per sec.
Uncompressed Bandwidth	Luminance: 30 MHz Chromance: 15 + 15 MHz
Chromaticity Coordinates	SMPTE 240M

If the computer and interactive video industry proves to be the driving force behind HDTV, it will likely be based on all digital technology. To fully exploit such a system it would probably require wideband transport services as offered by fiber optics.

If the entertainment industry proves to be the prime motivator behind HDTV, the equipment will likely be a hybrid of analog and digital signal processing, and pass through three stages of development:

- Production and editing of TV and motion pictures
- Home entertainment units
- Projector replacement in movie theaters

HDTV is a natural technology for replacing or at least supplementing film in the motion picture industry. Although there is some debate as to whether special effects, postproduction editing, and duplication is easier and cheaper to do with video signals than film, there is no doubt as to which provides the greatest versatility. The final product can be converted to celluloid for presentation in conventional movie theaters.

Once HDTV becomes widely accepted in the studio, it is only natural to want to use the magnetic tape as the video source rather than convert it to film prior to viewing. The development of large screen HDTV projectors would eventually replace the standard movie projector.

Today movies are viewed not only in theaters, but also in the home. Once there is a sufficient amount of HDTV material in the marketplace, HDTV home VCRs and television sets will emerge.

Of all the technical hurdles to be overcome, the question of bandwidth has received the most attention. Some of the factors affecting bandwidth include:

- Number of visible lines – a doubling of the lines quadruples the required bandwidth
- Aspect ratio – increasing this increased the number of equivalent vertical lines
- Scanning – progressive scanning uses twice the bandwidth of traditional interlaced approach

- Frame rate - a minimum frame rate equal to the power mains rate is needed to provide the illusion of motion while not producing visual beats
- Digital transmission – depending on the sophistication of the encoding algorithm used, a digital format requires approximately 10 times the bandwidth of an analog system

Some characteristics can be noted and used to reduce the bandwidth demands:

- Chroma information does not contain the same amount of detail as luminance
- Not all parts of an image require a high degree of resolution
- Detail cannot be observed when an image is in motion
- There is a high degree of spatial and temporal correlation over much of the picture, even when there is motion

In North America, the FCC has determined that broadcast HDTV must operate within the standard 6 MHz channel. Presently there are 12 VHF and 56 UHF channels. In order to prevent adjacent channel interference in a broadcast area, only every second channel is assigned in the VHF band and every sixth in the UHF band. Cable operators do not have this limitation because they have control over both the distributed signal quality and the transmission media.

The FCC has proposed that each existing TV broadcaster be assigned an adjacent channel in order to simulcast in both the regular and HDTV formats. This could begin as soon as 1996. The ultimate objective is to eliminate the conventional channel by 2008 and broadcast HDTV only. This transmission overlap allows users to replace their TV sets at their convenience.

Because of the difficulties associated with HDTV, some have suggested an intermediate step, EDTV.

HDMAC

This system has a baseband bandwidth of 16.8 MHz, which is reduced to 9.5 MHz by means of differential encoding.

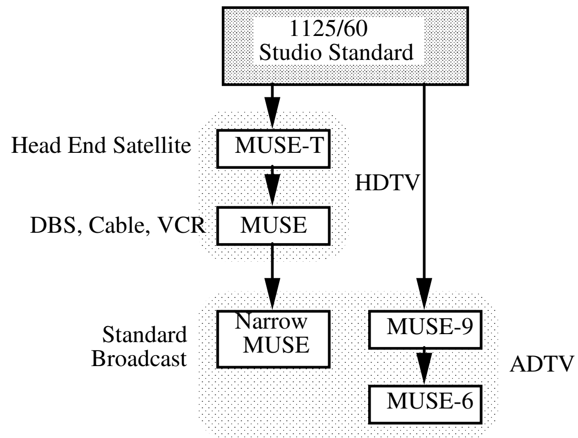
HDMAC	Comments[7]
E–MAC	The HDTV version of the MAC family. It contains 1250 lines, a 50 Hz field, 2:1 interlace, a 5:3 aspect ratio and uses a 45 MHz sampling rate.
S–MAC	This studio version of MAC uses an 11 MHz bandwidth in order to maintain the original sync and color burst signals for transcoding into PAL or SECAM.

MUSE E

Of all of the HDTV proposals in the offering, the Japanese MUSE† system developed by NHK†, is the most widely acclaimed. Like most HDTV

[7] *MAC Vision*, Electronics World + Wireless World, May 1990

proposals, MUSE exists in several versions of varying quality, forming a family. The lowest level in this family is generally referred to as ADTV†.



MUSE-E is the highest-level signal in the MUSE family, and has been successfully broadcast over satellite and fiber optic links for several years. This is a complex scheme employing motion-compensated sub-sampling and chroma time compression. Some of the features of this system include:

MUSE-E	
Picture	1125 lines [1035 active] 60 Hz field rate, 2:1 interlace 19:9 (5.33:3) aspect ratio
Sampling	1920 luminance samples per active line 960 color difference samples per active line digitized at 64.8 MHz sampling rate 1/4 [16.2 MHz] sent for transmission
Bandwidth	6 dB equivalent baseband bandwidth: 8.1 MHz Y: 20 - 22 MHz for stationary portions 12 MHz for moving pictures C: 7 MHz for stationary portions 3.1 MHz for moving pictures
Audio & Data	4 state DPSK at 2.048 Mbps PCM multiplexed in V blanking period

The receiver is equipped with a 4-field storage register and the missing samples are interpolated between the transmitted sample points. There is a loss of resolution when there is picture movement, but this may not be a great handicap since detail is difficult to detect when there is a lot of movement.

The major drawback of this system is that it is totally incompatible with conventional TV.

† Multiple Sub-Nyquest Encoding

† Nippon Hoso Kyokai [the national Japanese broadcasting authority]

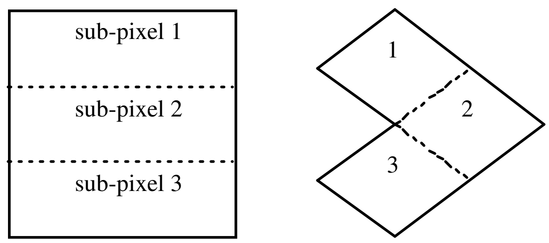
† Advanced Definition TV

HD-NTSC[8]

This approach allows for a somewhat backward compatible triscan system, by subdividing a pixel into 3 sub-pixels. The camera scans sub-pixel 1 during the 1st frame, sub-pixel 2 during the second frame, and sub-pixel 3 during the 3rd frame.

A standard NTSC set would be unable to distinguish between sub-pixels and would therefor simply see the standard number of lines, but a HD-NTSC set would be able to resolve more lines.

Subdividing Pixels



In order to obtain the larger aspect ratio (14:9) for HDTV, this system would simply cutoff a few lines on the top and bottom of the screen.

A2.3 Digital HDTV

All proposed HDTV systems use digital source coding to reduce the amount of information that is to be transmitted. However, systems using radio carriers use analog techniques to broadcast the signal. With the deployment of broadband fiber, the preferred transmission format is digital.

Although digital HDTV has a very high bandwidth requirement, there are some potential advantages:

- Digital signals can readily be regenerated and are therefore more immune to noise pick up or interference
- Multipath or ghost images can be more easily eliminated
- Reduced broadcast power requirements
- Can utilize LSI devices for signal processing and memory
- Multiple high quality audio channels can be accommodated
- Is compatible with the ISDN philosophy
- Interactive video services can more easily be supported
- Advanced cable TV services can be supported
- Control, data, and future services channels can easily be accommodated

8 *High Definition Tele-Vision*, Radio Electronics, February 1989

Digital HDTV Systems Comparisons[9]				
	Digicipher	**ADTV**	**DSC**	**Atva-P**
Sponsor	GI, MIT	Sarnoff, Thomson, Philips, NBC	Zenith, AT&T	GI, MIT
Aspect ratio	16:9	16:9	16:9	16:9
Lines per frame	1050	1050	787.5	787.5
Field rate [Hz]	59.94	59.94	59.94	59.94
Frame rate [Hz]	29.97	29.97	59.94	59.94
Scan format	2:1 interlace	2:1 interlace	Sequential	Sequential
H Sync Rate [KHz]	31.4685	31.4685	47.203	47.203
Luminance pixels [H x V]	1408 x 960	1440 x 960	1280 x 720	1280 x 720
Luminance bandwidth [MHz]	21.5	24.5 <23.6>	34	34 {31}
Chromance pixels [H x V]	352 x 480	720 x 480	640 x 360	640 x 360
Chromance bandwidth [MHz]	5.4	12.25	17	34
Video sampling rate [MHz]	{51.8} <53.65>	{54} <55.64>	{75.34}	{69.05} <75.5>
Video data rate [Mbps]	12.59/17.47 {13.8}	17.73 {14.98}	8.6/17.1 {17.2}	15.64 <18.88/13.60>
Audio bandwidth [KHz]	20	23	20	20
Audio sampling rate [KHz]	48	48	47.203	47.203
Audio data rate [Kbps]	503	512	500	500 <755>
Auxiliary data channel [Kbps]	126	256	413	126
Error Correction Overhead [Mbps]	<6.17>	<5.64>	<1.3/2.4>	<6.54>
Control data rate [Kbps]	126	40	40	126
Transmitted data rate [Mbps]	19.51/24.39	23.46 <24.0/4.8>	11.1/21	19.43 <26.43/21.15>

Numbers in { } taken from Video Engineering by Andrew F. Inglis pg. 322
Numbers in < > taken from *The New World of HDTV* by Audrey Harris, Electronics Now, May 1993.

DigiCipher System

This approach is sponsored by the ATVA[†], comprised mainly of General Instruments Corporation and the Massachusetts Institute of Technology.

The decimator reduces the bandwidth or resolution in the chromance [U & V] signals by a factor of 4 in the horizontal axis, and 2 in the vertical axis. The luminance signal bandwidth is reduced by eliminating redundant information in the image. This is accomplished by means of the DCT.

9 *Putting the Right Numbers into HDTV*, Electronics World + Wireless World, June 1992

† American Television Alliance

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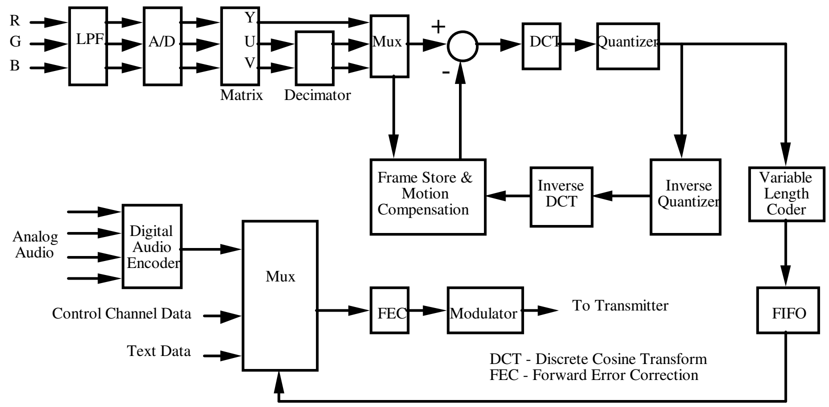
DigiCipher HDTV Functional Block Diagram[10]



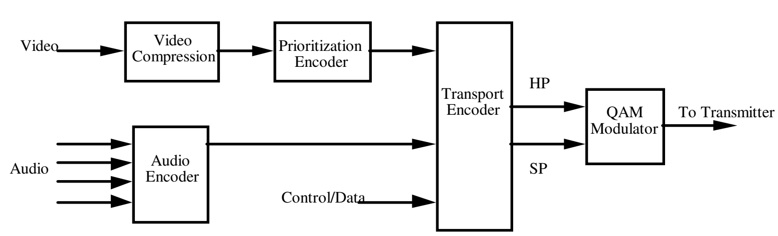
The DCT output is then applied to two separate signal-processing paths. One of these is the variable length coder, which uses an entropy coding algorithm such as Huffman coding, to reduce the number of bits to be ultimately transmitted. The following FIFO transforms this variable speed data into a constant rate.

The second path from the quantizer forms part of a feedback loop that also reduces the amount of video information to be encoded. The inverse quantizing and DCT functions are performed and the result sent to a motion estimator. This unit compares the present video frame with the previous, processed one. The common elements are determined and subtracted from the signal in the forward path, going to the DCT. In this way, the signal, which is being transformed, is only the difference signal between two successive frames. This feedback loop therefor acts as a two-dimensional delta modulator.

The entire digital bit streams; video, multiple audio channels, control, and data can then be multiplexed together. To minimize the effects of impulse noise, which can have a disastrous effect on any delta modulation scheme, forward error correction is used.

ADTV System [ATRC]

The fundamental difference between this approach and that of Digiciper is the prioritization encoder.



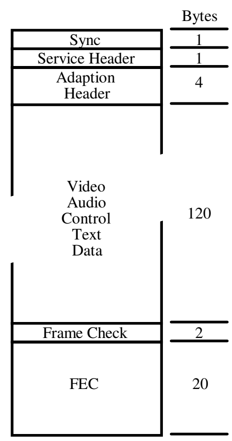
10 Based on Fig.1 *The New World of HDTV*, Electronics Now, May 1993

Notes

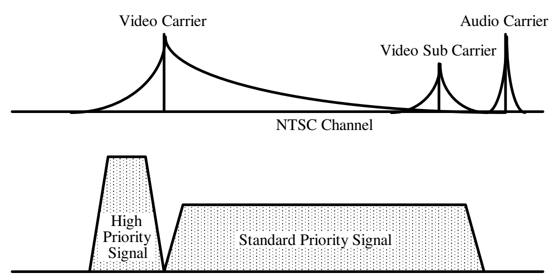
The video coding is based on the MPEG standard and is sometimes referred to as MPEG++. In order to handle scenes that have a great deal of motion in them, the digitized streams are separated into two different priority groups. Information necessary to maintain picture integrity; gray scales, audio, data headers, and motion descriptors is given a high priority. These are transmitted with a 5-dB higher level and are assigned to the vestigial sideband area associated with NTSC channels.

The low and high frequency coefficients from the DCT are broadcast in the standard priority band associated with the rest of the NTSC channel. The priority assignments are dynamically assigned. This allows standard priority signals to be shifted into the high priority area, if this region is lightly loaded.

The standard and high priority signals are each formatted into a 148-byte transport cell. These cells can both be passed on for further processing and transmitted on an NTSC channel or they can directly be passed on to a BISDN network.



The two data streams are used to QAM the analog carrier. The HP channel is band limited to 960 KHz and the SP channel is band limited to 3.84 MHz.



DSC System

This system uses progressive scanning. This eliminates inter-line flicker, and some motion artifacts, but at the expense of increased bandwidth. The image has 787.5 lines in a frame, and the line scan rate is 47,203 lines per second. This is three times the present line rate thus allowing for relatively easy conversion. Unfortunately, other HDTV systems are attempting to double the

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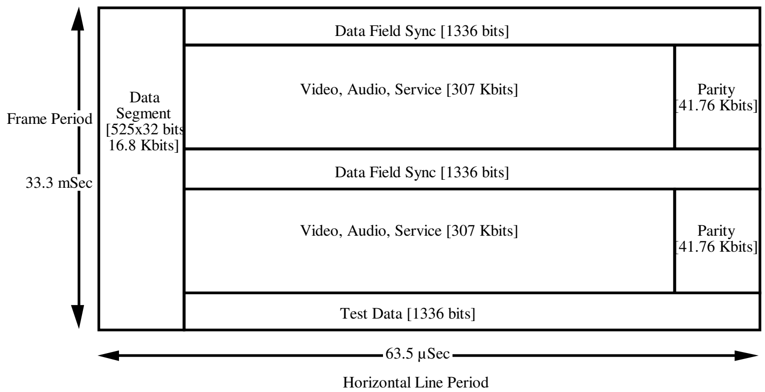
present image resolution to about 1000 lines, whereas this system achieves an improvement by a factor of 1.5.

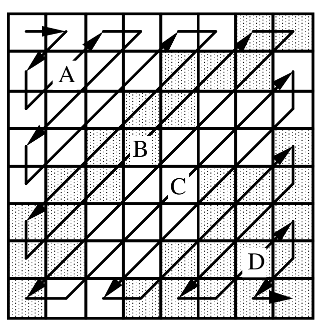
Another difference with DSC is how it formats the digital information after the DCT. It organizes it into blocks corresponding to the NTSC time frame.



The above format has the additional advantage that because the timing requirements are identical to standard NTSC, there does not have to be any head changes in the HDTV VCR. This means that a digital recorder will be able to both record and playback standard and NTSC and HDTV formats. No need to throw away those old tapes or have two VCRs!

CCDC System

This is essentially the same as DSC system except for the treatment of the DCT coefficients. The block area is divided into four frequency bands each comprised of 16 elements. These are readout diagonally since diagonal elements correspond to amplitude coefficients of nearly the same frequency.



The Huffman coding scheme is applied to each of the 4 areas.

A2.4 Digital HDTV Grand Alliance

http://www.sarnoff.com/career_move/tech_papers/hdtv.html

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A1.4 Grand Alliance

The grand alliance consists of a consortium of companies, which are developing a digital North American HDTV standard.

The latest version of their standard is located below:

The technologies that are at the heart of the digital high-definition television (HDTV) system expected to be adopted by the Federal Communications Commission reflect the Digital HDTV Grand Alliance's commitment to system excellence and responsiveness to the needs and concerns of consumers, broadcasters, cable operators, computer interests and the telecommunications industry. Key system elements include:

Digital video compression technology based on international standards. The compression system used in the Grand Alliance system will be based on MPEG-2 (Moving Pictures Experts Group) Main Profile parameters, including the use of "B-Frames." (B-Frame or Bi-directional Frame motion compensation is a compression technique that improves picture quality.)

High-performance digital modulation technology for broadcasters and cable operators. Developed by Zenith Electronics Corporation, the modulation subsystem used in the Grand Alliance HDTV system, the 8-VSB (vestigial sideband) transmission technology, is rugged digital technology for terrestrial broadcasting that assures a broad HDTV coverage area, reduces interference with existing analog broadcasts and provides immunity from interference into the digital signal. The higher-data-rate cable mode, 16-VSB, will allow operators to transmit two full HDTV signals in a single 6-MHz cable channel.

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Telecommunications-like packets of digital data based on proposed international standards. A packetized data transport system that allows the transmission of virtually any combination of video, audio and data packets -- similar to those used in state-of-the-art digital data communications networks -- will concentrate on features and services of MPEG- 2 that are applicable to HDTV and provided for in the MPEG-2 transport layer.

Progressive scanning for computer interoperability. The Grand Alliance uses both progressive and interlaced scanning. The formats are 24-, 30- and 60-frame-per-second progressive scan with a pixel format of 1280 x 720 (number of active picture elements per line times the number of active lines), and 24- and 30-frame-per-second progressive scan with a pixel format of 1920 x 1080. The system will also be capable of 60-frame- per-second interlaced scan with a pixel format of 1920 x 1080. These formats provide a good foundation for the migration to a 60-frame-per-second 1920 x 1080 progressive format as soon as technically feasible.

Compact-disc-quality digital surround sound. The Grand Alliance system will use the 5.1-channel Dolby AC-3 audio technology.

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Assignment Questions

1. Sketch one line of the British C-MAC signal format.
2. MUSE has a baseband bandwidth of [6.7, 8.1, 10.2] MHz
3. Define MUSE [Multiple Sub-Nyquist Encoding].
4. Explain the operation of the DCT.
5. Determine the current status of HDTV in North America in general and Canada in particular.

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For Further Research

ATSC Digital Television Standard, Advanced Television Systems Committee, Document A/53

System Information for Digital Television ATSC Standard, Advanced Television Systems Committee, Document A/56

Advanced Television Systems Committee http://www.atsc.org/

ATSC Documents http://www.atsc.org/stan&rps.html

Advanced Television Technology Center http://www.attc.org/

http://www.inforamp.net/~poynton/Poynton-video-eng.html

http://www.cs.ubc.ca/spider/mjmccut/video.html

http://www.cemacity.org/mall/product/video/hdtv.htm

http://web-star.com/hdtv/battle.html

http://www.sarnoff.com/

http://cctpwww.cityu.edu.hk/public/graphics/g2_video.htm

http://dvlive.com/

http://www.quantel.com/dfb/a.htm

HDTV Newsletter http://web-star.com/hdtv/hdtvnews.html

http://www.current.org/atv1.html

NHK HDTV http://www.nhk.or.jp/hi-vision/hivi-e.html

Zenith http://www.zenith.com/

Cable Labs http://www.cablelabs.com/

HD Vision http://www.hdvision.com/

http://ourworld.compuserve.com/homepages/AMagliocco_Jr/

http://www.thetools.com/

http://www.ee.washington.edu/conselec/CE/kuhn/hdtv/95x5.htm

http://www.d2mac.com/

http://gehon.ir.miami.edu/com/classes/cbr535/hdtv.htm

http://195.0.94.6:80/hdtv/