CHAPTER 5

HIGH DEFINITION TELEVISION SYSTEMS (HDTV)

5.1 Introduction

The criteria by which a system is considered high definition television (High Definition Television) have been defined in Rec. CCIR 801 in 1986 :

- The spatial resolution should be about 4 times higher than traditional television systems SDTV (Standard Definition Television) NTSC, SECAM, PAL.
- Display device with large surface
- Image aspect ratio close to that of widescreen cinema (which has Widescreen aspect ratio of 1.85) and Cinemascope (Cinemascope aspect ratio of 2.35). 16: 9 has been accepted for HDTV systems compared to the 4:3 aspect ratio for SDTV systems which was comparable to the classic format (Classic or Academy aspect ratio 1.375)
- Higher brightness and contrast
- Better color display
- Stereo sound with a quality compatible to that of a Compact Disc

Image resolution must increase by at least 2 times in each direction horizontally and vertically. In this way the optimal distance to which the image is reduced to 3 times the screen height (compared to 5 times the standard television SDTV. The number of lines of exploration should be about double the conventional systems, the horizontal viewing angle is 30 degrees, and the video bandwidth has to be 5 times higher than in the SDTV systems.

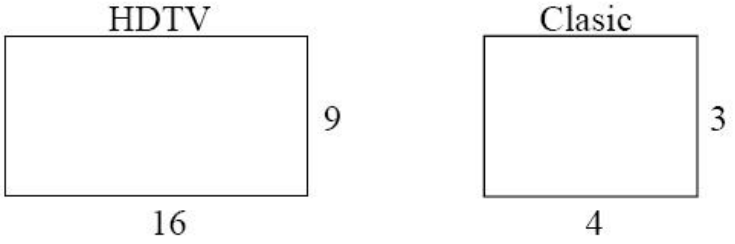

Fig. 1

The image must not have effects as those encountered in conventional systems: diafotia crossluminance, crosschrominance, flickering of the bright areas.

All these conditions imposed changes to the image sensors and to the image display devices in terms of resolution and aspect ratio, and to the studio equipment.

The condition of large diagonal screen surface greater than 1 meter imposed and new solutions for flat panel display devices, color picture tube being excluded from large diagonal screens due to their weight and depth.

The conditions imposed by the CCIR Recommendation 801 were necessary in order to distinguish between true HDTV systems and other TV systems which make only small modifications of the existing SDTV systems. In the US Advanced Television Systems Committee (ATSC) established in the same period definitions for such systems:

a) IDTV television systems (Improved Definition Television) were systems that deliver improvements to NTSC (can be extended to PAL or SECAM) which remain within the general framework of the system: improvements in encoding, filtering for increased signal / noise ratio or frame frequency twice as for the SDTV systems in order to eliminate image flicker for high brightness areas.

b) EDTV (Extended Definition Television) systems with a resolution extended which bring improvements that are not compatible with NTSC such as increasing the aspect ratio of the image, increasing the resolution both horizontally and vertically by a factor less than 2 or any other improvements.

5.2 Short history of HDTV

The first HDTV system was created in Japan in the early 1980s. It was called MUSE (Multiple Sub Nyquist Sampling Encoding = Encoding with multiple sub-sampling). It was a system with aspect ratio of 5: 3, 1080 active lines / 1125 lines in total with 60 Hz and interlacing. The sound was digital but the video signal was transmitted as analog samples. To reduce the transmission band to 10.8 MHz (one HDTV channel thus fall within two 6 MHz

radio frequency analog channels in standard M available in Japan) multiple sub-sampling is performed using the property of the video signal spectrum that is not continuous, but has narrow spectral bands up to 6 Hz located at multiples of the line frequency, field frequency and linear combinations of them.

In 1986, at a Conference WRC (World Administrative Radio Conference), Japan tried to impose MUSE as a world HDTV system. Because of US and Europe opposition this has not happened. Din cauza opoziției SUA și a Europei acest lucru nu s-a întâmplat. At that time, US and Europe began research to create an HDTV system and in this context appeared CCIR Recommendation 801 in 1986.

In Europe Eureka 95 program was launched, and the system called HD-MAC HDTV (High Definition MAC) was created, a system with transmission of analog video samples and digital sound. Systems of MAC (Multiplexed Analogue Components) type such as D2-MAC or C-MAC were already used at that time on direct television satellites in Europe to deliver better quality television SDTV. The HD-MAC system was designed as an evolutionary system compatible with the MAC. The 1250 lines video signal with field frequency 50Hz interlaced was converted by interleaving samples of two successive lines in a video signal with 625 lines, for decoders compatible with MAC and SDTV receivers. If viewers have HD-MAC decoder and HDTV receiver, the signal is converted back into a HDTV signal with 1250 lines. MAC and HD-MAC were used on direct television satellites in Europe until the early 1990s.

In the US research has continued in parallel with those in Europe and was created in 1982 Advanced Television Systems Committee (ATSC). In the early 1990s, Americans have concluded that a HDTV system should be a digital one, especially that video compression standards MPEG-1 and MPEG-2 had emerged.

For this reason they developed a video digital compression MPEG-2 signal with picture formats with 1080 active lines or 720 lines with interlace or progressive scan, symbolically marked 1080i, 1080p, 720i or 720p. The frame rate may be 24 Hz, 25 Hz, 29.97 Hz, 30 Hz or 50 Hz for interlaced, 59.94 Hz, or 60 Hz for progressive scan. According to CCIR Recommendation 801 a system with 720 lines is not a true HDTV system, it can be considered a HD ready system.

5.3 Signals in HDTV

In the HDTV system were chosen other primary colors than in SDTV in order to expand the area of the display colours in the colorimetric color chart. White reference has changed and is the DGS white. Because on the relative visibility curve of the eye, the new primary colors have different weights than those for SDTV, the luminance signal has the expression:

$$E_Y = 0{,}21\ E_R + 0{,}72\ E_G + 0{,}07\ E_B$$

The amplitude of the luminance signal is between 0V and 0.7 V, ie 0.7 Vpp and the line synchronization signal has ± 0.3V (H synchro pulse with 3 levels).

Because color difference signals have a range of ± 0,35V, ie 0.7 Vpp, as the luminance signal, for the standard color bars test pattern, the color difference signals were weighted by coefficients and resulted the PR and PB signals:

$$E_{PR} = 0,63\ (E_R - E_Y)$$

$$E_{PB} = 0,538\ (E_B - E_Y)$$

HDTV Standards

HDTV standards define scan parameters, analog interface, parallel interface and serial interface for processing digital and high definition video signal in the studio. The TV digital studio standard defined in Recommendation CCIR 601 and adopted by CCIR (International Radio Consultative Committee) - currently ITU - T (International Telecommunication Union - Telecommunication) - provides the following parameters:

1. aspect ratio……16:9
2. sample number on active line…….…….1920
3. sampling…….ortogonal
4. coding system……..R, G, B or Y, C_R, C_B
5. scan…… interlaced 2:1
6. field frequency……..30 or 25 Hz
7. lines/frame…….1125 or 1250

The bandwidth for HDTV analog, red, green and blue is 30 MHz for interlaced formats (1080i lines) and progressive scan (720 lines), and for progressive scan (1080 lines) is 60 MHz. Therefore it is necessary a high sample rate to digitize HDTV luminance and color difference signala.

Media types

The 35mm cinema film has higher resolution than HDTV systems and is designed with 24 frames per second. In order to be delivered on television in countries that use 50 Hz interlaced (25 Hz frame rate), the film is accelerated by 4.1% in the telecinema system of TV studio. The

acceleration is acceptable because only lead to an increase of this percentage in the movements in the image.

In countries using 60Hz interlaced (frame rate 30 Hz) the rate of 30 frames per second would be too much and acceleration would be visible, so there is a technique called "3: 2 pull-down" whereby every second frame (photogram) with 24 Hz video creates three 30 Hz film-video conversion (telecinema).

From the 36 digital video formats defined by ATSC, 12 are HDTV formats, presented in Table 5.1

Table 5.1

Format Level	Vertical Pixels	Horizontal Pixels	Aspect Ratio	Scan Mode	Frame Rate
HD	1080	1920	16:9	Progressive	24 or 23.98
HD	1080	1920	16:9	Progressive	30 or 29.97
HD	1080	1920	16:9	Interlaced	30 or 29.97
HD	720	1280	16:9	Progressive	24 or 23.98
HD	720	1280	16:9	Progressive	30 or 29.97
HD	720	1280	16:9	Progressive	60 or 59.94

HDTV parameters of a digital line for different formats

The parameters are presented in Table 5.2, with T the sample period.

Table 5.2

Format	Frecvență [MHz]	A	B	C	D	E
1920x1080 60 1:1	148,5	44T	148T	280T	1920T	2200T
1920x1080 59,94 1:1	148,5/1,001	44T	148T	280T	1920T	2200T
1920x1080 60 2:1	74,25	44T	148T	280T	1920T	2200T
1920x1080 59,94 2:1	74,25/1,001	44T	148T	280T	1920T	2200T
1920x1080 30 1:1	74,25	44T	148T	280T	1920T	2200T
1920x1080 29,97 1:1	74,25/1,001	44T	148T	280T	1920T	2200T
1920x1080 50 1:1	148,5	448T	148T	720T	1920T	2640T
1920x1080 50 2:1	74,25	448T	148T	720T	1920T	2640T
1920x1080 25 1:1	74,25	448T	148T	720T	1920T	2640T
1920x1080 24 1:1	74,25	594T	148T	720T	1920T	2640T
1920x1080 23,98 1:1	74,25/1,001	594T	148T	830T	1920T	2750T
1280x720 60 1:1	74,25	70T	212T	370T	1280T	1650T
1280x720 59,94 1:1	74,25/1,001	70T	212T	370T	1280T	1650T
1280x720 50 1:1	74,25	400T	212T	700T	1280T	1980T
1280x720 30 1:1	74,25	1720T	212T	2020T	1280T	3300
1280x720 29,97 1:1	74,25/1,001	1720T	212T	2020T	1280T	3300
1280x720 25 1:1	74,25	2380T	212T	2680	1280T	3960
1280x720 24 1:1	74,25	2545T	212T	2845	1280T	4125
1280x720 23,98 1:1	74,25/1,001	2545T	212T	2845	1280T	4125

The existence of archives of videos in SDTV format required the introduction of conversion equipment (up-conversion) from SDTV to HDTV by creating additional interpolated lines and change the aspect ratio. Even if this conversion does not improve the picture quality so as to be identical to the native HDTV (captured HDTV), video signals are obtained compatible with HDTV studio production.

5.4 UHDTV systems

In Japan since 2004 it tests were made with the NHK television system called Super Hi - Vision for HDTV systems, in Japan HDTV systems are called Hi - Vision. These tests were made with better image resolution than HDTV and with surround sound systems 22.2.

In 2007 SMPTE (Society of Motion Picture and Television Engineers) defined the UHDTV (Ultra High Definition Television) standards 4K and 8K.

In 2012, ITU has agreed the formats for UHDTV Level 1 system (4k) and Level 2 (8k system).

For the 4K the system is 2160p (2160 lines with progressive scan) 3840x2160 resolution (8.3 megapixel), and for 8k the system is 4320p (4320 lines with progressive scan) and resolution 7680x4320 (33.2 megapixel). The 8K system has the image quality comparable to 70mm film used in IMAX cinema systems.

For those resolutions, special image sensors and display devices need to be developed.

It also needs a better standard video compression than MPEG-4 AVC (Advanced Video Coding). This is the new standard MPEG HEVC (High Efficiency Video Coding) with a compression ratio 50% higher than AVC.

It is also necessary to upgrade the HDMI connection to 1.4a for the 4k display devices.

The 4K systems are considered UHDTV level 1 systems, and many TV equipment manufacturers developed TV receivers and equipment for broadcasters for this level.

The UHDTV level 2 systems will have a greater color gamut, higher contrast and better sound systems. The standards for this second level are in progress.