Practical experiences in digital TV

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As a result of the arrival of television sets with flat, panoramic and digital screens, I undertook a series of tests to verify the characteristics of these digital television sets and the reception of aerial terrestrial television in high definition, comparing the obtained visual results. In these tests only the video image had been evaluated, no other complementary functions of the transmission system of digital video, nor the audio. Then its objective is to comprise only the visual attributes of the digital television.

Introduction

The television set used in these tests was a Philips 32 inches LCD television. It has 16:9 format (called wide or *panoramic*), a tuner for analog channels, and inputs for analog and digital video.
The technical characteristics of the TV are:
Model: *32PF5321/77* LCD Television and monitor HDTV.
Standards of reception for antenna: PAL N, PAL M y NTSC
Bands of tuning: VHF, UHF, Hyperband (for cable).
Standards for the input in compound video: PAL N, PAL M, NTSC, PAL B.
Input for components: Y, Pb, Pr
Input RGB (WXGA) for connection to computers
Input HDMI (DVI - D) for connection to digital video equipment.
Pixels quantity on screen: 1366 *768
Native resolution: 1280 *720p
Maximum resolution: 1920 *1080i
Size of the area of screen: 69.8 x 39.3 cm
Consumption: 120W (1W in waiting mode)

Several options in video interconnections exist, and this set presents a variety of inputs that enable the connection of practically any video normalized source.
It brings inputs for compound video and for analog components, as well as inputs for digital video through a HDMI connector. The input for analog components can be at the video format of PC, RGB, or in the one for television Y, Pb, Pr, in 1 fh, 2fh and 3fh. If the input is not in a supported format, it announces this fact by a message on screen.

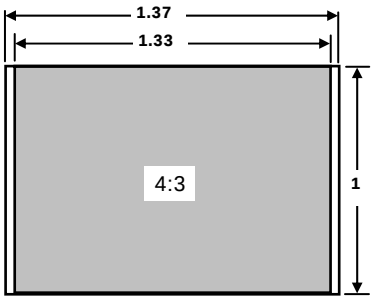
An important characteristic to take in account is the dotpitch, witch determines the screen quality. From the measurements and characteristics supplied by the manufacturer, its dotpitch is of 0,51mm, (50dpi max.).
The tests from the PC was contrasted with a SONY VGA monitor *Multiscan 200ES* of 17 " with a dotpitch of 0,24mm (106dpi max.), and using 1152 *846 resolution (90dpi).
The screen of the PC monitor has 32.5 cm in width and it has 1360 points, against the 69.8 cm of the LCD television set for the same spotted amount.
That means that the PC monitor has almost the same spotted amount than the TV, but in 1/3 of its surface and that therefore it has better resolution (we would say twice the amount!).
Then a good option to see HDTV is on a PC monitor (preferable more than 17 “).
If the TV had the same spotted density (or the same max dpi.) than the PC monitor you would have some 2,900 horizontal pixels and 1,630 vertical pixels. I believe that those numbers will be showed in the next generation of screens for 1080p.
I stand out that as the definition in the PC monitor is larger, the minimal distance of observation decreases drastically, allowing many more small objects to be seen than on the TV set.

Formats

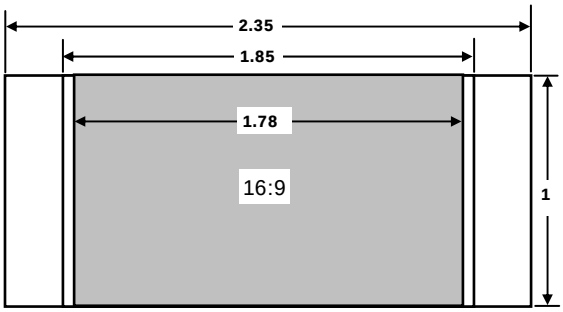
In the migration to digital form, we have to fight against these two aspect ratios or “formats” when we refer to television in standard definition, the 4:3 and the 16:9, (HDTV is only 16:9).
Two methods are used, the letterbox (to emit material with 16:9 format on a 4:3 screen) and the anamorphic (to transport a 16:9 video material in a 4:3 medium). It is convenient to emphasize that the 4:3 format is also 12:9.

With this proportion, when comparing 12 and 16 it is easy to see that it is ¼ less or 1/3 over, according to how they are compared.
This television set, like all wide screen sets, allows the picture to be seen in several modes.
In the 4:3 mode, the image becomes centered with a square format, but it misses 1/4 of available screen.
The expanded mode -in this television set it is named “Super Zoom”- exists in order to bear this. It consist basically of stretching the right and left-hand extremes of the image to cover the entire screen. It is a drastic solution, since it distorts the image a little by the extremes, but it is the format that I commonly use to watch television.

Of course it has the 16:9 mode, but if the material does not have this factor, you lose the top and bottom of the picture. This mode is used to display material delivered in letterbox format.
Also it has an intermediate option, the 14:9 mode, which stretches the image to cover more horizontal area losing part of the picture vertically (but not occurring if material is in letterbox format).
Another one is the subtitles mode, which enlarges the picture too, but raises it up to view the subtitles, commonly located at the bottom of the screen.
Finally, it has the anamorphic mode; it allows to display the complete image in 16:9 when the material was compressed horizontally to 4:3 (12:9). The digital video cameras, like the one used for these tests, has this format, allowing panoramic too recording. Then, this format is suitable to display the video on 16:9 screens, being the format 4:3 only for transport.
This has had a great effect in the production of material for DVDs, where it is mentioned as 16:9 Wide formats.



Academy (1.37) and
Standard NTSC PAL (1.33)



American cinema (1.85)
and Cinemascope (2.35)

The tests

The analog input from a VHS player was used for the first test. It can be in compound video or in S-video, this screen allows the subtle quality differences to be seen between both connections.
The analog video does not have pixels; here the definition is determined by its bandwidth.
The maximum definition taken from the compound video comes from its 4 MHz of bandwidth, but using a VHS signal with around 2.5 MHz of bandwidth, it has a maximum discrimination of 4.4 pixels, that is, on the screen there are no points minor to 2.7 mm.
This demands the screen to be seen at a great distance so as not to appreciate the pixelation, the minimal distance is around 6 or 7 times the height, that is, for 32"screens it is around 3 mts, with an angle of vision of some 14 degrees (practically, like any analog television set).

Afterwards, I connected a miniDV PAL camera (*TRV 20E*) through S-video. Here the bigger resolution of the source and the best bandwidth of the connection allowed to discriminate a point size of only 1.7 pixels, that is 1 mm at the screen, and a minimal distance close to 2 mts, with an angle of vision of 17 degrees.
The enhanced quality in the colors was appreciated, and details were outstanding. This is called video with digital quality and standard resolution, and corresponds to the PAL B (standard of the used camera), to 720 *576i total pixels (but there are only 704 *568 on screen).

Since this TV does not have an IEEE1394 input, the miniDV camera cannot be connected directly, but using the input of the computer and loading the video in a file, now quality can be appreciated totally in digital form through the VGA output (RGB).
Even though the VGA output is not digital, instead it is by analog components, (like all the VGA-PC monitors), the quality provided by the available bandwidth makes it comparable to a digital connection.
A video downloaded from the camera was used for this test. With a bit rate of 25Mbps and 720*568 resolution, that is better than the one delivered from a DVD (<9 Mbps).
The VGA output (RGB) of the PC was connected to the RGB input of the TV set in PC mode.
The video format was selected in 1280 *720p this was chosen firstly by being the native resolution of the TV. But in PC mode, the TV has only two modes: the wide, where the screen stretches 16:9, and the normal, that reduces it to 4:3.
The manufacturer recommends using 1024 *768 for the PC thinking about the compatibility with the square screens that are presently used. However, the tests had accomplished in the wide format because I want to use the maximum of visual coverage.
I selected the DualView mode of the video board in Windows, delivering simultaneous output to both screens.
Even though quality got better, in fact it was marginally. By looking at the desk of Windows the minor resolution of the TV was appreciated facing the PC monitor.
Even though I can read the letters of the icons, it is enough with getting a little closer, to see a blot. The minimal distance got better, but pixelation in the fine print is highly clear.
In the reproduction of the video material, quality is very good. The deficiency of typical vibrations, noticeable in analog TV is gone, and the high definition of the pixels on screen is clearly visible. Here the minimal distance diminished, ranking below 2 meters.

Video in high definition

Next, I reproduced downloaded material in high definition in 1080i format. The output of the computer was selected in 1920*1080 to get out the maximum of quality.
And it really was the first moment where I appreciated the quality of the LCD screen.

Even though the simultaneous reproduction on the PC monitor allowed to see that it is superior in definition, the size of the 32”screen, covered up totally with 16:9 material and without the letterbox effect, left the PC monitor out, in the high definition race (mainly for the size of the image).

Here the definition is at most perfect, the least details appraise, like the rivets of the fuselage of an airplane, or the pores in the skin in a foreground. Here the purity of the colors and the details of the objects impress (for example, brilliances and reflections over polished surfaces).
The minimal distance now comes to 0.5 mts (limited by my presbysia) and the resolution of the interlaced screen seems better than 720p.

From the perspective of pixels quantity, the format 1080i supports a better space resolution than the 720p. In fact, in the meantime the 1080i has 2.07 Megapixels, the 720p has only 0.92 Mpix. This screen accomplishes the reconvertion of the 1080i signal to the native format with excellent quality.
This gives me the idea that an image in 720p has minor resolution substantially, although necessarily it does not have to be worse than 1080i. It depends very much on the material of the program. A screen in 720p should theoretically yield an image with less blinking when you have twinkles.
In reality, it is difficult to detect the differences in the details between 720p and 1080i if you are seated at 3 meters from the screen. We have to get closer to the screen and have a good-quality material to appreciate differences.
I should say that, in spite of the best temporary resolution of the 720p, I did not find deficiencies in the material in 1080i, still in very fast motions, this can be for the characteristics of the digital processing of the television set.

I did not try the digital input through a DVI D to HDMI cable because I still do not have it. The digital connection, without compression or reconvertion, will be another improvement to try.

The following test ran with signal from analog television, connecting the antenna input to “Cablevision” cable company. In spite of the fact that it has a good quality, its lacks resolution, low saturation, and noise in the plain colors are factors that stand out, as characteristics of the analog TV.
At the optimal distance of observation now increased to some 4 mts, and at less than 2 mts, the noise begins to be really annoying to be seen. This is really a big screen to watch television, and perhaps one is not used to seeing so much in detail.

As this television set refreshes the screen not in line frequency, we do not fail to see the typical lines of sweeping of analog TVs, then this defect, as well as the one belonging to blinking, are surpassed and they enable a vision in great size, without plotted.

Reception in high definition

At a later time and thanks to the contribution of the Eng. Guidobono of the ATSC Forum, I had access to an ATSC standard decoder to accomplish reception tests of the signal emitted by Channel 13, Buenos Aires (channel 13 VHF) in the VHF channel 12. The provided decoder was a Samsung model SIR T150 HDTV Decoder.
Its brief technical characteristics are:
Bands of reception: VHF - UHF
Outputs: 480i, 480p, 720p, 1080i
Consumption: 40 W
Year of manufacture: 2001
Price: u$s 699 (upon launching, now around u$s 149).

It has a 15 pins connector, VGA style, with an RGBHV output, a video output in components (Y, Pb, and Pr), an S-Video output, and a compound video output, that ensure you that it may be connected to any television set.
This tuner is a third generation one, which is why it is not “the state the art” of the decoders in this standard, in which the rejection to ghosts has been improved very much.
I was planning to use the components output in 1080i for the tests, because it is the format that the channel transmit and is the best that this LCD TV can manage.

The objective was to verify the performance of the television set, and the visual characteristics of the reception of terrestrial digital TV.
For the reception of the signal, originally I thought about a Yagi type antenna, but like the first day, in front of the haste of verifying if there was a signal, I used an indoor antenna composed by a dipole, constituted by two telescopic pliable rods with 0dB of gain. I took the precaution of extending the connecting cable with an adapting balum 300:75 and 3 mts of coaxial cable. That way I put the antenna on the domicile's terrace where the tests were performed at Almagro neighborhood in the downtown of the Buenos Aires City. The antenna was left at the height of a third floor (near 9 mts) and in front of other higher buildings.
Knowing that I can find the transmitting antennas in the same geographic place, I used firstly the analog TV signal from channel 13 to guide it and to adapt the telescopic elements in order to improve the signal as much as possible.
Next, I connected it to the digital tuner and the signal was trouble-free. The level of signal in the receiver gave a mark of 50 %, enough to receive the transmission with absolute stability. The tuner has a led that indicates the quality of the signal, which should be in green. At seeing it kept green, I discarded the need of another antenna.
According to the information given by Eng. Guidobono, the used power in the digital transmission is lower than 1KW, reason why the reception would be able to be called marginal in terms of the low emission. However, there were no problems of interferences (neither of impulses, neither ghosts).
When searching opinions from other users on the Internet about this decoder, I found similar comments to the characteristics observed by me.

The contents of the emitted material upon the reception start were a series of promotions, some reconverted to high definition, using the 19,39Mbps. As the channel transmits in 1080i, the decoder was selected in this definition. The TV did not need any adjustments, since it is automatic, showing always the image correctly.

The first impressions on the quality of the pictures were their purity and definition, watching the visual

difference, among the qualities of the emitted material.
For example: in a football match (reconverted) I observed that the typical handsaws appeared by pixels deficiency in the borders of the diagonal objects (looking at the display screen closely).
While in a F1's race with the camera of high definition mounted over the pilot's head, the indication of the digital speedometer at 1 meter from the camera, in the shade, and with an actual size of some centimeters, is appreciated trouble-free. It would not be possible to distinguish these numbers in standard definition.
I obtained the same material from the Internet and it looked exactly the same. This showed me that the digital transmission system does not degrade the quality of the video, at all.
Texts are something that causes an impact too, appearing so quiet and defined that they look like coming from a PC, not from a TV signal.
With its purity and plenitude of colors, the high definition transforms the experience of watching television in an infinite detail happening, giving to television the possibility of the movie film detail.

Since the material was relatively short in duration (around 10 minutes) and it was repeated cyclically, I had been able to observe it several times, in such a way so as to know to the details that I wanted to appreciate more.
I took some onscreen photos to be able after to compare results, finding a small problem with distance (focus in macro) and mixes between the pixels, with color bars appearing in some shots, which were not noticeable at the real TV picture.

A video clip of the film Titanic shows you how to dump from a film to HD video without losing definition, not only that, it looks better than in movies, because the screen of the TV is small (compared to a movie screen) and you can come closer, up to some centimeters from it, and even see the image as it would a photo, without degradation.
What is more, you can appreciate the little typical black spots of a moving picture, which certifies its dump from the film. When the material is generated natively in high-resolution, video quality is perfect.

Later the material transmitted by the channel 12 was changed, emitting several simultaneous channels (multicasting), in this way they are called virtual channels (the DCC of System Information Protocol - PSIP). Thus a teledifusor can emit, for example, one program in high definition and two in standard quality. In this case, it dealt with a basketball match in high definition, a news bulletin in standard definition and a weather map. The channels were defined to the correspondent virtual channel number 5, the digital channels were 5-1, 5-2 and 5-3 (the 5-0 would be the analog). And I could see three channels perfectly, with one in high definition (although all at the channel 12 of VHF), where now there is one.

After these multiple emissions, they proceeded to emit a promotional material of Mexico, showing beautiful views of this country. The material was originally HDTV as the above-mentioned characteristics allow.
The tests continued carrying the antenna to inside of the house. Here the decoder sensibility was put in test, since a reception of analog television under these conditions is impossible. However, the digital reception, even though deteriorated by the susceptibility to the people’s motions in the room, continued delivering an acceptable image.
Also, I took the opportunity to measure the signal delivered by the decoder ATSC with an oscilloscope, obtaining the pictures for 1080i and 720p.

Conclusions:

The experience was highly informative in relation to the characteristics of the large LCD TV screens, which nowadays allow to watch video in different ways. Using material from VHS, cable television, miniDV, videos downloaded from Internet, DVD, up to terrestrial television in high definition, taken from antenna (and what antenna!).

Really the habit of watching television in high definition is a way of no return, although the fact that at the moment I do not care about the possibility of watching video in my cellular phone, I definitely said “yes” to high definition at home in my television set. I am convinced that this is what people will want to see, as soon as they can.
It is evident that to provide other services, the rate of bits transmitted by broadcaster, for television pictures,

should be lowered, degrading the perfomance. Then, we have to decide what we want: more added services or bigger resolution. I vote for the bigger resolution!
The great size of these LCD screens demands that the signal be at least digital and preferably in high definition, otherwise they will be destined to be used to display in front a numerous audience and at some distance (and not in the living room of my house).

Even though the vertical sweep in ATSC is 60Hz, and in my country we have 50Hz, I perceived no any types of shake or flame on screen.

Watching analog television in a 14" television set (20cm of height) at 3 mts of distance, gives a good-quality image impression, but one 32" TV (40 cm of height) would need to be seen at 6 mts to feel the same impression, then the details and the possibility of watching big scenes, would definitively go away.
Although the advanced sweeping system of this TV improves the picture a lot.

These new big LCD television sets advantages the previous with TRC, like being very low consumption, having a useful longer life, very shallowness, not having dangerous emissions and not being susceptible to electromagnetic fields. Thanks to the improvements in the presentation this TV avoid blinking and the sweep lines are not noticeable.
The bad thing: The angle of vision with a good contrast, is very thin, I expect this will be solved with the next LCD screens enlightened with Leds. Also, there is a delay of some milliseconds that becomes notable if it is watched simultaneously with one analog TV (most of all in the audio).

I deduced that the analog television is for analog television sets, because a digital television set (and big) shows all its limitations.
Although this digital screen has the same amount of pixels than a TRC, it has better broadband and more stability, in addition to the improvements on pixels optimization, the contrast of color and the discriminating levels (called for Philips "Digital Crystal Clear") allow to see 1920 x 1080i with a surprising quality.

I believe that the next step in high definition will be the 1080p that has all advantages, good space and temporal definition. And it will arrive when the algorithms of compression (like the MPEG 4/AVC or H264) allow fitting it into the rate of available bits. Now that we are talking about it, the screens will have to be of ultra definition to be able to appreciate it.

Regarding the rate of available bits, a given compression for a given resolution is a compromise that should be taken into account. The compression, finally, analyzes how many bits are needed for the current reproduction, which is limited basically by the bit rate. If the motion is fast and the bit rate is insufficient, a pixelization in the correspondent part of the image will be observed. If the entire image has low resolution this will not be notable, or if the rest of the image is motionless, maybe there be a margin for it. But in high definition the quantity of bits is important, a small difference can be notable. Also, of course, the kind of encoding used.

The best encoding way should be to attain the maximum of performance in a transmission channel, which is given by Shannon's formula. Well, nowadays, the best method for it, is to use the Turbo Codes design, the ones that are intended to be applicable in the A-VSB to implement the movable and portable reception (ATSC M/H). Surely this will also benefit home reception.

Even though the used antenna was the simplest possible, it worked satisfactorily. If I had a better system (like a diversity antenna), certainly the reception, still from insides, would be possible with good stability.

Although the digital transmission does not improve the original material, it avoids the degradation during its diffusion through analog systems. Therefore, watching digital TV is like seeing it at home with the quality it had at the TV studios.

A possibility to watch high definition is to use the PC, right now as the formats of video files, (like the Windows Media Video), enable to access material in HD and be able to display it in our computer (or in one TV connected to it).

To watch digital TV with standard definition is similar to seeing the shots from a digital home camera, or a DVD. But as recording in high resolution yet eludes the home amateur, and the HD-DVD are not on the market yet, to see high definition in a great TV is an experience that attracts the attention.

These tests allowed me to confirm that the technological change will be a great step in how to watch television. the day when we will have access to hundred of available channels in high definition and in real time will come, in a future it will take place and we will get used, by the moment we are witnessing the change, imagining how the next television will be like.

Technical appendices:

Visual acuity
The visual acuity corresponds to the quantity of sensors in the eye, which corresponds to an angular visual acuity of 1/60 (1' minute of grade).
Then the minimal distance of observation can be calculated with:

D (H 2 NL) so (/2) 3437 H NL

Where:
NL: Lineage horizontal
d: Distance of minimal observation cm
h: Height of the screen cm

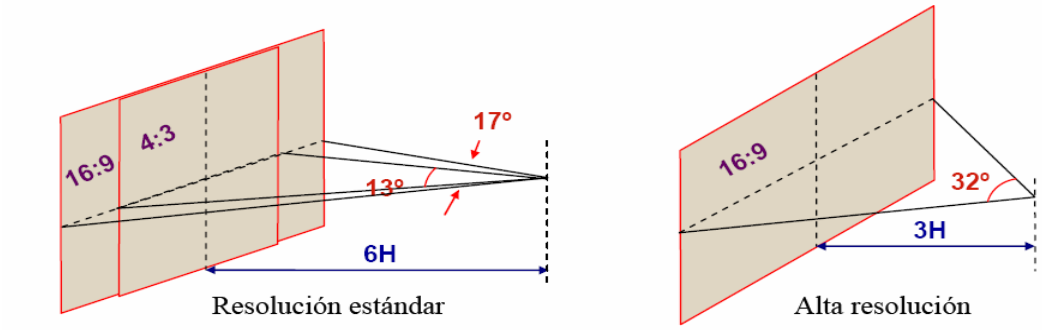
Standard definition: 3437 * 40 cm/ 568 = 242 cm

Improved definition: 3437 * 40 cm/ 720 = 190 cm

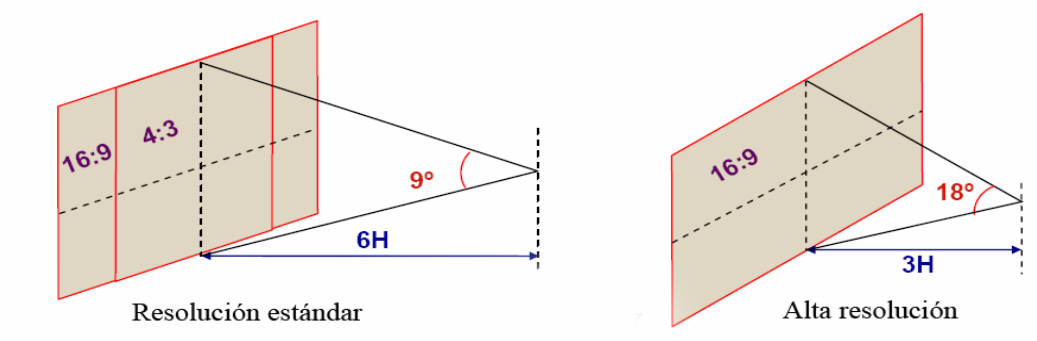
High definition: 3437 * 40 cm /1080 =127 cm

Conclusion: The minimal distance of observation in high definition is a half than in standard definition.

Angle of horizontal vision



Angle of vertical vision:



High definition:

According to the standard ITU R BT.709-5:

> "A system designed to observe the image at a distance of approximately **three times** its height, so that the system is virtually or almost virtually transparent to the quality of the presentation that would have been perceived in the scene or original performance, to an observer with visual normal acuity."

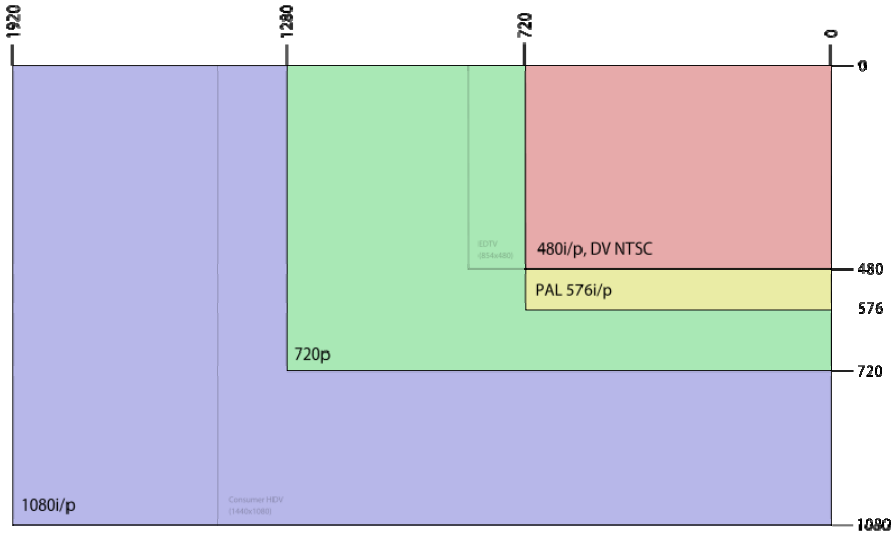
Anamorphic Format:

Example: Original image in 16:9 and with anamorphic compression in 4:3:

16:9

4:3

Relative sizes of different video resolutions:



Resolutions of the TV LCD:

Resolución de pantalla compatible

- Formatos informáticos

Resolución	Frecuencia de actualización
640 x 480	60, 67, 72, 75 Hz
800 x 600	56, 60, 72, 75 Hz
1024 x 768	60, 70, 75 Hz
1280 x 768	60 Hz

- Formatos de video

Resolución	Frecuencia de actualización
640 x 480i	1Fh
640 x 480p	2Fh
720 x 576i	1Fh
720 x 576p	2Fh
1280 x 720p	3Fh
1920 x 1080i	2Fh

Photos:

Television set of 32" 32PW5321

Decoder ATSC Samsung SIR T150

Rear connections of the TV

(All the photos were taken with a SONY DSC P73 camera in 4,1 Mpíxeles.)

Definition of the TV, showing an area of 7x11 cm.

Detail of the film TITANIC

Sight of the full screen in 1080i

Detail view of the side image

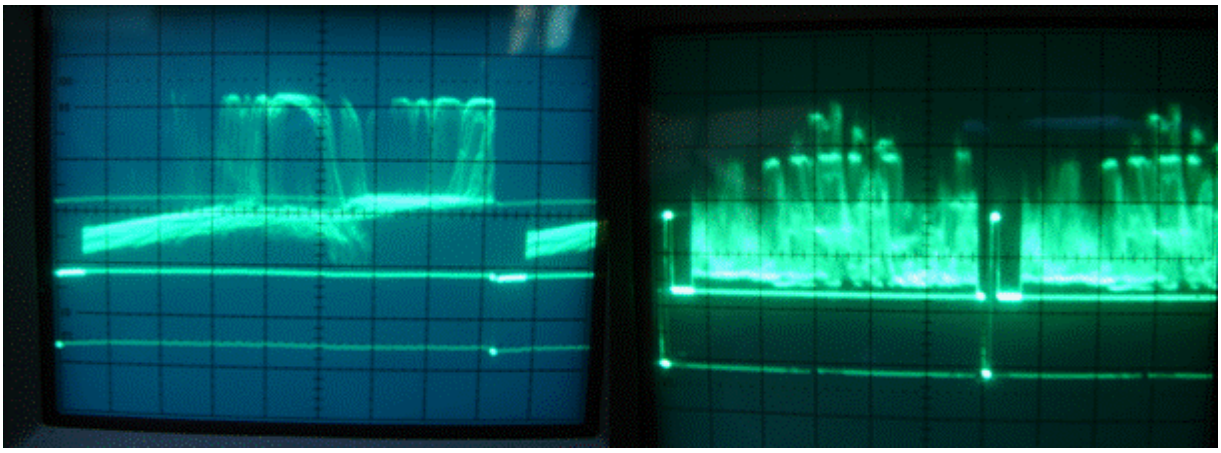
Images with great motion, on the left just a person dipping water, on the right a very fast motion scribble the background but you can see the water absolutely neat.

Text in 1080i (see the ruler, it have 2 cm high)

The same text in 480i is scribbled

General view of a beach, photo shot at 80 cm. In the next views we see a detail of the parachute instants after.

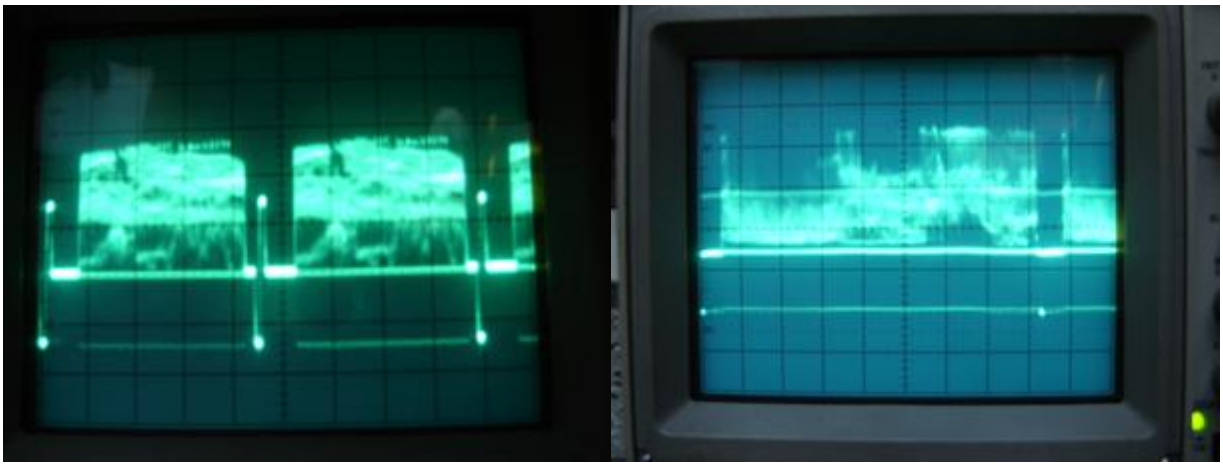
In 1080i you can read the Bacardí mark in the fabric of the parachute and the clearness of its limit is seen against the blue of the sea. In 720p resolution it is more scribbled. Both photos shot with the camera about 15 cm. of the screen.



ATSC decoder output, taken with a *Tektronix 2235 A* Oscilloscope.

Vertical sweep - 2ms /division (1080i)
Correspond to 60 Hz.

Horizontal sweep - 5us /division (1080i)
Correspond to: 31. 5 KHz. (2fh)



Horizontal sweep - 5us /division (720p)
Correspond to 47.25 KHz (3fh)

Vertical sweep - 2ms /division (720p)
Correspond to 60 Hz.

Image degraded with noise (Bad reception).

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