DIGITAL TELEVISION

What is digital TV?

Digital TV (DTV) refers to digital representation and processing of the signal as well as its digital transmission. Digital TV broadcast involves converting images and sound into digital code. This digitization of images and sound (and data) starts with compression in order to minimize the capacity required of the transmission channel. In all advanced digital TV systems, compression is performed to the industry standard MPEG-2, then modulation occurs whereby the code is formatted for propagation along terrestrial, satellite or cable media.

The DTV transmission standard uses digital processing and compression to achieve simultaneous transmission of several different television programs or reception of a single program at a picture quality level that depends on the complexity of the receiver. In any event, the quality of the signal received is equivalent to the studio output. New technologies have recently brought tremendous flexibility in the use of different picture formats using digital compression systems. Moreover, because of the digital nature of the picture information and the emergence of powerful high-speed processors, the computer industry is directing its main business to the TV world. These converging technologies are modifying the existing TV environment completely.
Why Digitalize?

- Better Picture Quality (High Resolution) even for weak signal,
- Digital signals consist of binary pulse train that can be made immune amplitude degradation by regeneration of pulses.
- Stereo sound quality.
- Digital data easy to store, delay and transmit and to manipulate (Conversion NTSC-PAL)
- They can be time multiplexed.
- No need to transmit blanking and sync. signal.
- Advanced features like teletext and picture in picture.

Digital TV Standards:

- ATSC: Advanced Television System Committee (North America).
- ISDB-T: Integrated service Digital Broadcast (Japan & Brazil)
- DVB-T: Digital Video Broadcasting (Europe, Russia, Australia and India)

In Digital TV system, the only difference between NTSC and PAL is the scanning lines.

Fully Digital System:

An analog signal suffers degradation in transmission path due to noise. In fully digital system the analog signal is converted into digital signal by means of an A/D converter.

Three basic tasks of A/D converter are: a. Sampling  b. Quantization c. Encoding.

a. **Sampling Rate:** Nyquist uniform sampling theorem: A signal band limited to \( f_m \) Hz is uniquely defined by its samples taken uniformly at \( 1/f_m \) seconds apart. If the sampling rate is less then this Nyquist rate, the analog signal can not be reconstructed with out errors.

b. **Quantization:** The discrete time sampled output is continuous in amplitude. By quantization, the continuous amplitudes are assigned discrete numerical values. This introduces quantization error.
c. **Encoder:** After Quantization, the sampled numerical values are assigned binary code along with additional coding for error detection.

   When an error is detected, the system can either hide its effect or request for retransmission. But, delay is not acceptable in TV. Hence, coding process with forward error correction has its benefits and limitation.

   i. Block coding
   ii. Convolution coding.

**Digital Signals**

The first technical stage of digital broadcasting is to convert video signal that changes between 25 and 30 frames per second according to broadcasting standards into digital signal encoded as 1 and 0 bits. In other words, images like the ones as shown in Figure 1, are divided into the smallest parts or points called “pixels”. Color and brightness of each of these pixels are defined to achieve a digitizing process.

For example, in an image frame with broadcast quality, there are 720 points horizontally and 576 points vertically that total 414,720. If a broadcast quality of 25 frames per second is assumed, point number defined by 1 byte reaches to 10,368,000. In short, a digital video image of 1 second contains information of 10 million points. In order to broadcast digital audio and video carrying such a large amount of information, a very large bandwidth is required. This is a significant point for transmission lines with limited bandwidth. Therefore, in order to solve this problem, compression techniques are used.

**Digital TV signal & Transmission:**

The digitization of TV signals can take two forms: *composite* or *component* signals.

**Composite Signals:**

In composite coding, the composite NTSC, PAL or SECAM signals are quantized, the resulting digitized signals are referred to as “**Digitized video**”.

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For composite digital television, we use a clocking frequency of four times the subcarrier frequency. The color subcarrier frequency in NTSC is 3.58 MHz and in PAL its 4.43 MHz, but in both cases we take samples at four times the subcarrier frequency. This is where the term $4f_{sc}$ comes from. So for an NTSC signal, we take samples at 14.3 MHz. (In PAL, $4f_{sc}$ is 17.7 MHz.)

**Component signals:**
In component coding, the Luminance and chroma signals (Y, U, V) or Red, Green and Blue (R, G, B) from the camera are separately digitized; these digitized signals are referred to as “All-digital-video”. Noise reduction and special video effects are easier in component coding.

In component television there is no subcarrier, and a sampling frequency of 13.5 MHz was chosen as a useful frequency that “works” in both the 525 and 625-line worlds. For the chrominance components, Cb and Cr, usually only half of the sampling rate is used, that is, $f_{s,c} = f_s / 2$. This leads to half the number of pixels in each line, but the same number of lines per frame. This is known as the 4:2:2 format, implying that there are two Cb samples and two Cr samples for every four Y samples. To further reduce the required data rate, BT.601 also defined the 4:1:1 format, in which the chrominance components are subsampled along each line by a factor of four, that is, there is one Cb sample and one Cr sample for every four Y samples. This sampling method, however, yields very asymmetric resolutions in the horizontal and vertical directions. Another sampling format has therefore been developed, which subsamples the Cb and Cr components by half in both the horizontal and vertical directions. In this format, there is also one Cb sample and one Cr sample for every four Y samples. But to avoid confusion with the previously defined 4:1:1 format, this format is designated as 4:2:0. For applications requiring very high resolutions, the 4:4:4 format is defined, which samples the chrominance components in exactly the same resolution as the luminance components. The relative positions of the luminance and chrominance samples for different formats are shown in figure.
Digital Transmission Systems

In DVB-C (Cable), DVB-S (Satellite), DVB-T (Terrestrial) and other transmission systems data are transmitted in two ways. The first is via cable using traditional copper coaxial or optic fiber cables; and the second is wireless via airwaves or satellite. Data transmitting rates, capacities, coverage, service lives and costs are different from each other. Transmission systems can be used for transmitting digital television data together or separately. Digital transmission is the transmission of analog or digital data in the form of digital signals. Digital transmission speed is usually measured in bits per seconds or symbols per second, either one referred to as data rate. The data rate can be either in bits per seconds (bps) or in bauds (or simply baud rate). Baud rate is defined as the number of symbols per second. Data rate in bits per second is also called the bit rate.

DVB-C (Cable) transmits a number of channels to viewers through satellite compatible cable and its most important feature is that it has interactive broadcasting infrastructure. DVB-T (Terrestrial) has 7-8 MHz bandwidth and uses MPEG-2 format. It enables broadcasting more channels via low powered terrestrial transmitters using VHF and UHF bands. DVB-S (Satellite) transmits data directly or indirectly through satellite using MPEG-2 compression format on 11-12 GHz Ku band.


### Digitized Video Parameters (CCIR 601)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Coded Signals</th>
<th>Y, Cb, Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Samples/line</td>
<td>858 (NTSC) /864 (PAL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for color components: 429 / 432</td>
</tr>
<tr>
<td>2</td>
<td>Active samples</td>
<td>720</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for color components: 360</td>
</tr>
<tr>
<td>3</td>
<td>Quantizer</td>
<td>Uniform PCM, 8 bit/sample (Y,Cb,Cr)</td>
</tr>
<tr>
<td>4</td>
<td>Gray levels Scale</td>
<td>0 -255</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y:220 Q levels (black:16, gray-white:235)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cb,Cr:225 Q levels (zero: 128)</td>
</tr>
<tr>
<td>5</td>
<td>Sampling frequency</td>
<td>Luminance-13.5 MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chrominance-6.75 MHz</td>
</tr>
</tbody>
</table>

### The digital TV Receiver

It is not convenient to change the analog TV receivers with the digital counterparts which will have prohibitive high prices. Instead, a simpler solution, which uses an additional digital Set-Top-Box to the present analog TV receiver, is found to be more economical during the transition period.

![](Set-Top-Box.png)

Set-Top-Box plus Analog Receiver alternative to Digital TV receiver
In this solution the Set-Top Box converts the digital signals coming from Cable, satellite or Terrestrial transmitters to conventional analog TV signals and may be watched by standard TV receiver.

A Set-Top Box consists of three main parts:
- High Frequency Tuner and Demodulator,
- Transport Demultiplexer, MPEG Decoder
- Microcontroller and other Peripherals

The input of the set top box is the digitally modulated RF signal coming from the channel. The box processes this signal and gives base band analog audio/video signals as well as PAL/NTSC encoded and modulated UHF/VHF standard analog TV signal for the standard TV receiver. It also provides communication signals for Pay-TV and Video-on-Demand applications.

FLAT PANEL DISPLAYS

LCD Display

Liquid crystals are substances that exhibit a phase of matter that has properties between those of a conventional liquid and those of a solid crystal. For instance, a liquid crystal may flow like a liquid, but its molecules may be arranged and oriented in a crystal-like manner. There are many different types of liquid crystal phases, which can be distinguished based on their different optical properties.

Principle: The liquid crystal molecules are electrically charged. By applying an electric current to transparent electrodes over each pixel or subpixel, the molecules are twisted by electrostatic forces. This changes the twist of the light passing through the molecules, and allows varying degrees of light to pass through the polarizing filters. Before an electric current is applied, the liquid crystal molecules are in a relaxed state. Charges on the molecules cause them to align themselves in a helical structure, or twist. If the liquid crystals are completely untwisted, light passing through them will be polarized
perpendicular to the second filter, and thus be completely blocked. The pixel will appear unlit. By controlling the twist of the liquid crystals in each pixel, light can be allowed to pass through in varying amounts, correspondingly illuminating the pixel.

In color LCDs, each individual pixel is divided into three cells, or subpixels, which are colored red, green, and blue, by additional filters. Each subpixel can be controlled independently to yield thousands or millions of possible colors for each pixel.

Depending on the location of the light source, LCDs are either transmissive or reflective. Transmissive LCDs are illuminated from the back by a backlight and viewed from the opposite side (the front). This is the type of LCD used in TV, computer displays, and mobile phones. These applications require high luminance levels, and the illumination device usually consumes much more power than the LCD itself. Reflective LCDs are often found in digital watches and calculators; they are illuminated by external light which may be reflected by a diffusing reflector behind the display. These LCDs have higher contrast than the transmissive types, and significantly lower power consumption.

**Plasma Displays**

A plasma display is an emissive flat panel display where light is created by phosphors excited by a plasma discharge between two flat panels of glass. A mixture of noble gases
(neon and xenon), which is inert, is used to produce the gas discharge. Plasma displays do not use mercury.

The word “plasma” refers to an ionized gas, and is usually considered to be a distinct phase of matter. It refers to a system of charged particles that is large enough to behave collectively; even a gas in which as little as 1 percent of the particles are ionized can behave as a plasma and have the characteristics of a plasma. Examples of plasmas found in nature include flames, lightning, the Northern Lights, and the sun and stars. Plasma displays are bright, have a wide color range, and can be produced in fairly large sizes (up to 80 inches). The display panel is 2 1/2 inches thick. Plasma display panels use as much power per screen area as a CRT; the larger screen sizes can use up to 700 watts of power, enough to make some critics worry about the environmental consequences of wide adoption of plasma displays. In addition, plasma displays are susceptible to screen burn, a phenomenon where images can be permanently imprinted on the screen if the device is left on for too long a period.

**Principle:** Plasma displays contain xenon and neon gas in hundreds of thousands of tiny cells positioned between two plates of glass. Two types of long electrodes are also sandwiched between the glass plates, on both sides of the cells. The “address” electrodes are located behind the cells along the rear glass plate, while the transparent “display” electrodes are mounted above the cell, along the front glass plate. The display electrodes are surrounded by an insulating dielectric material and covered by a magnesium oxide protective layer.

In a monochrome plasma panel, the electrodes that cross paths at a cell are charged by the control circuitry, causing the plasma to ionize and emit photons between the electrodes. The ionizing state is maintained by applying a low-level voltage between all the horizontal and vertical electrodes, even after the ionizing voltage is removed. To erase a cell, all voltage is removed from a pair of electrodes. This type of panel has inherent memory and does not use phosphors.
To ionize the gas in a color panel, the electrodes that intersect at a cell are charged thousands of times in a small fraction of a second, charging each cell in turn. When the intersecting electrodes are charged, an electric current flows through the gas in the cell. The current creates a rapid flow of charged particles, which stimulates the gas atoms to release ultraviolet photons.

The phosphors in a color plasma display give off colored light when they are excited. Each pixel is made up of three separate subpixel cells, each with different colored phosphors (red, green, and blue). By varying the pulses of current flowing through the different cells, the control system can increase or decrease the intensity of each subpixel color to create hundreds of different combinations of red, green, and blue, across the entire visible spectrum. Electronic control of the pixels is relatively simple, and therefore manufacturing is inexpensive compared to other display technologies. Plasma displays use the same phosphors as CRTs.