

EE1002: Part 2

Lecture 3



香港城市大學
City University of Hong Kong

專業 創新 胸懷全球
Professional · Creative
For The World

- Analog television transmission
- Frequency division multiplexing
- Digital signals
- Analog-to-digital conversion
- Digital-to-analog conversion
- Nyquist rate
- Quadrature amplitude modulation (QAM)
- Time-division multiplexing (TDM)
- Digital television

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Invention of Television



Philo T. Farnsworth (left), an American inventor, first demonstrated transmission of a picture over the air in 1927, which marks the beginning of television transmission.

Television Transmission

TV Transmission

Specifications:

No. of transmitters	: 2
Power of transmitters (HPT)	: 10 KW
Height of mast	: 150 m
Height of antenna	: 15-20 m
Range of Transmitter	: 80-100 Km

TV Transmitters are classified on the basis of their Power of Operation:

High Power Transmitter (HPT)	: 1 kW, 5kW, 10kW, 20 KW, 30kW
Low Power Transmitter (LPT)	: 100W, 300W, 500W
Very Low Power Transmitter (VLPT)	: 10W, 50W



Analog Television Transmission

TV Channels	Spectrum	Band
2, 3, 4	52 – 74 MHz	VHF – Low-band
5, 6	76 – 88 MHz	VHF – Low-band
7 – 13	174 – 216 MHz	VHF – High-band
14 -51	470 – 698 MHz	UHF band

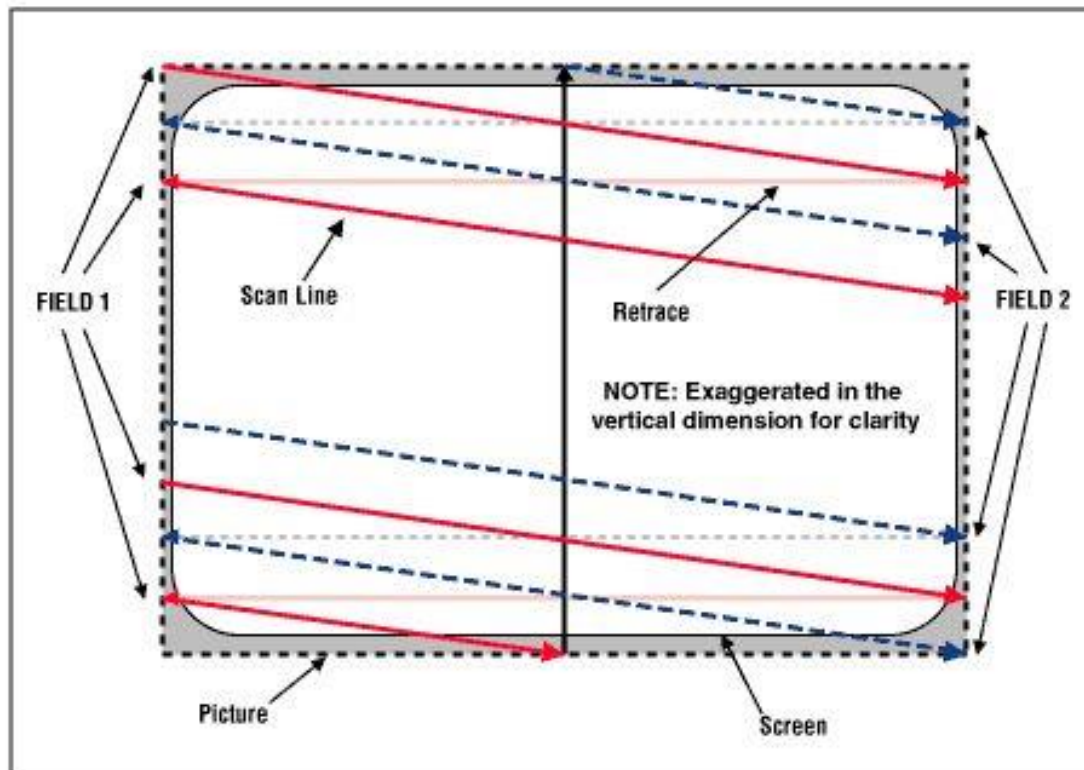
Television transmitters use both AM and FM; the video signals are transmitted by AM and the sound by FM.



Video on TV broadcasting: <https://www.youtube.com/watch?v=OmV9aJCXHlg>

Analog Television Transmission

Video signals are transmitted by a technique called interlacing. The technique can double the perceived frame rate of a video display without consuming extra bandwidth. The interlaced signal contains two fields of a video frame captured at two different times. This enhances motion perception to the viewer, and reduces flicker.



**Progressive Vs. Interlaced -
What's The Difference? (3.5 min)**
<https://www.youtube.com/watch?v=0DcUtsMLX74#t=204.1191737>

Video Broadcast Standards

the **NTSC - National Television System Committee** standard was introduced in the United States in 1953. It is used by many countries on the American continent as well as many Asian countries including Japan. NTSC runs on 525 lines/frame.

System	NTSC
Lines/Field	525/60
Horizontal Frequency	15.734 kHz
Vertical Frequency	60 Hz
Colour Subcarrier Frequency	3.579545 MHz
Video Bandwidth	4.2 MHz
Sound Carrier	4.5 MHz

<http://www.hometechanswers.com/video/standards.html>

Video Broadcast Standards

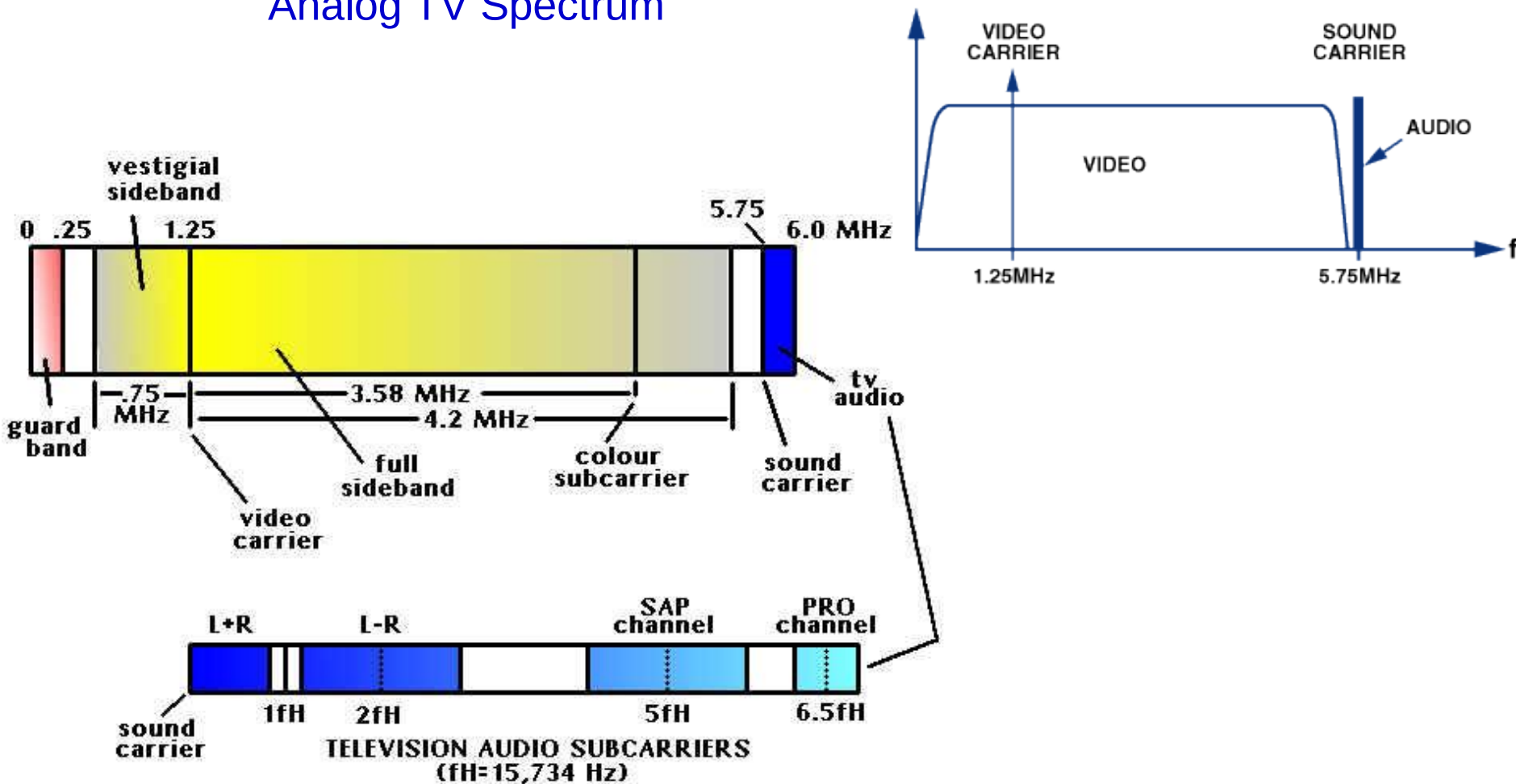
The **PAL** - **Phase Alternating Line** standard was introduced in the early 1960's and implemented in most European countries except for France. The PAL standard utilizes a wider channel bandwidth than NTSC which allows for better picture quality. PAL runs on 625 lines/frame.

System	PAL B,G,H	PAL I	PAL D	PAL N	PAL M
Line/Field	625/50	625/50	625/50	625/50	525/60
Horizontal Frequency	15.625 kHz	15.625 kHz	15.625 kHz	15.625 kHz	15.750 kHz
Vertical Frequency	50 Hz	50 Hz	50 Hz	50 Hz	60 Hz
Colour Sub Carrier Frequency	4.433618 MHz	4.433618 MHz	4.433618 MHz	3.582056 MHz	3.575611 MHz
Video Bandwidth	5.0 MHz	5.5 MHz	6.0 MHz	4.2 MHz	4.2 MHz
Sound Carrier	5.5 MHz	6.0 MHz	6.5 MHz	4.5 MHz	4.5 MHz

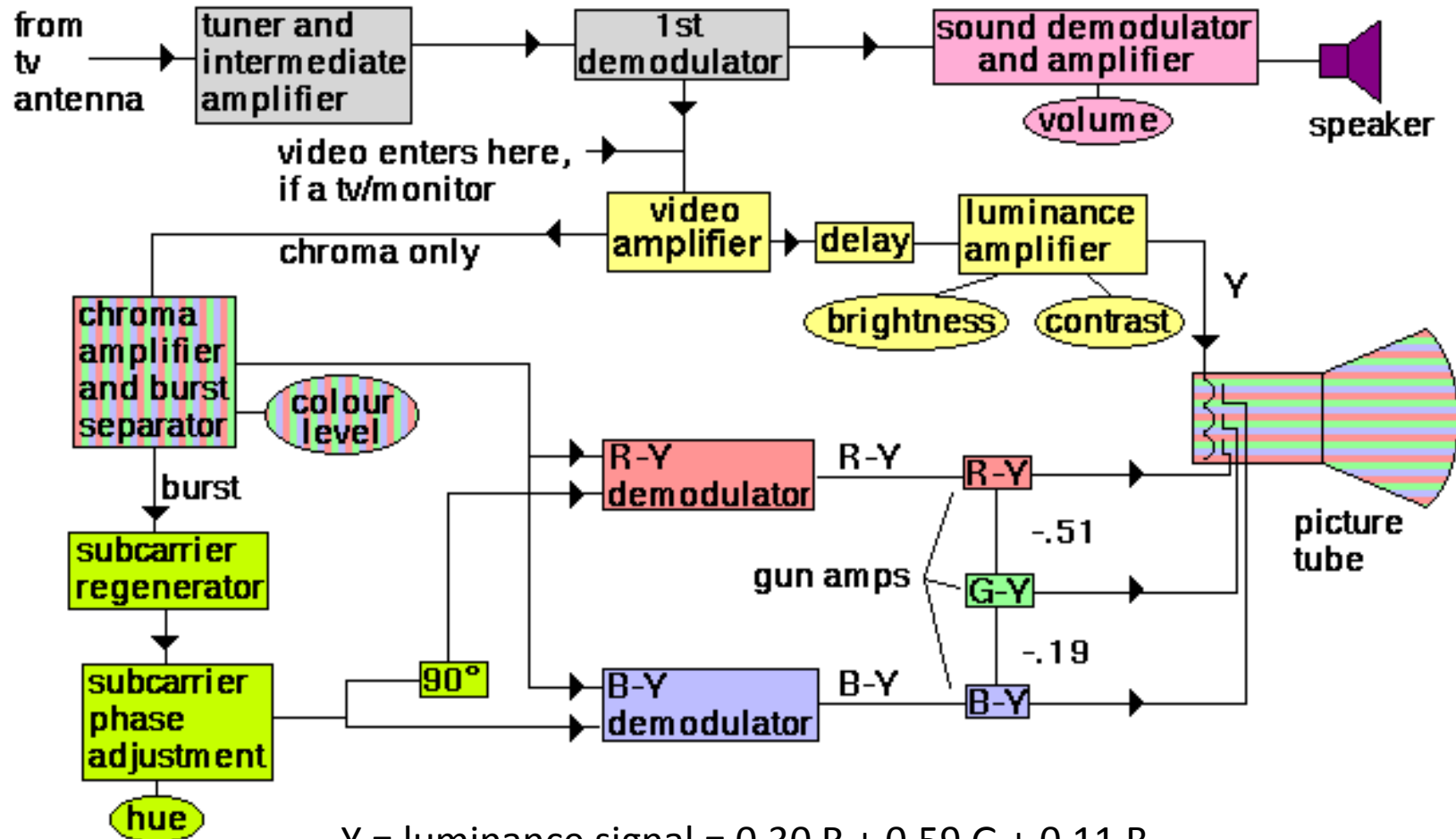
The **SECAM** - Sequential Couleur Avec Memoire or **Sequential Colour with Memory** standard was introduced in the early 1960's and implemented in France.

Analog Television Transmission

Analog TV Spectrum



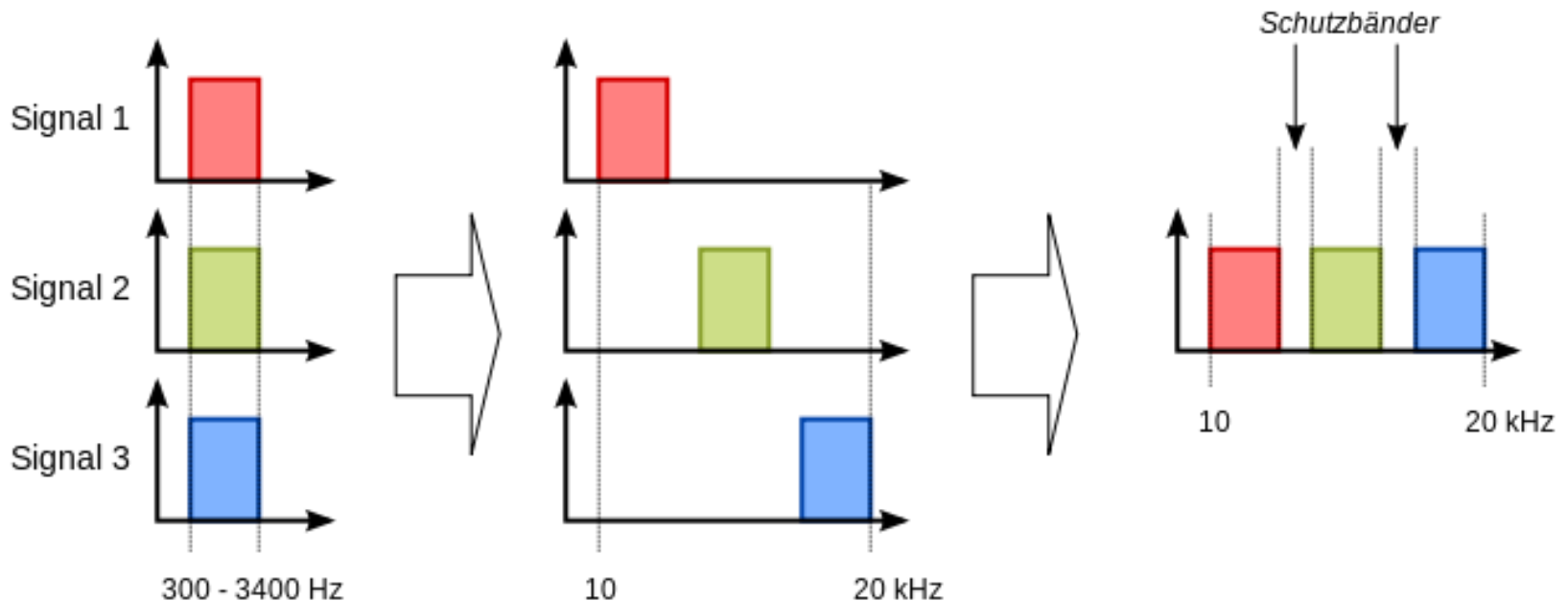
Analog Television Transmission



$Y = \text{luminance signal} = 0.30 R + 0.59 G + 0.11 B$
 $R, G, B = \text{signals for primary colours R, G and B}$

Frequency-Division Multiplexing (FDM)

Frequency-division multiplexing (FDM) is a technology that combines several signals into one medium by sending signals in several distinct frequency ranges over a single medium. One of the most common applications for FDM is traditional radio and television broadcasting from terrestrial, mobile or satellite stations, or cable television. Only one cable reaches a customer's residential area, but the service provider can send multiple television channels or signals simultaneously over that cable to all subscribers without interference. Receivers must tune to the appropriate frequency (channel) to access the desired signal.



Problems with Analog Transmission

Analog transmission is a transmission method of conveying voice, data, image, or video information using a continuous signal that varies in amplitude, frequency, or some other property of the carrier in proportion to the amplitude of the source signal.

Problems with analog TV reception:

Snow – This can be described as a faint image that sometimes fades to black and white. This most often is a sign of weak reception.

Ghost – This is a very common problem in areas with large buildings, tall trees, hills or valleys. The signal bounces off of various surfaces and creates multiple images.

Different frequency components travel at different speeds and suffer from different levels of attenuation.

Amplification also amplifies noise; filtering out just noise, in general, is a complex problem.

Problems with Analog Transmission

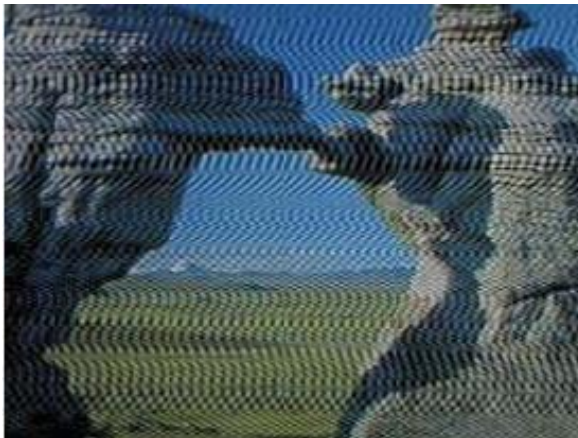
Normal picture



Weak signal



Interference



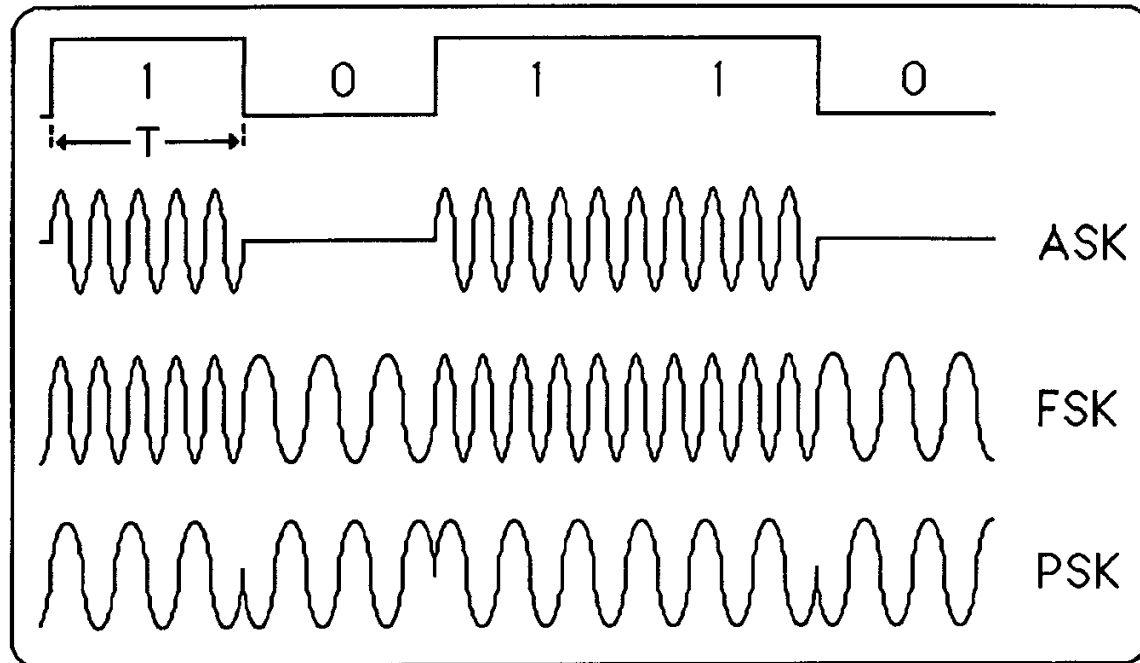
Ghost image



<http://www.qsl.net/g0isw/g0iswtviemc.htm>

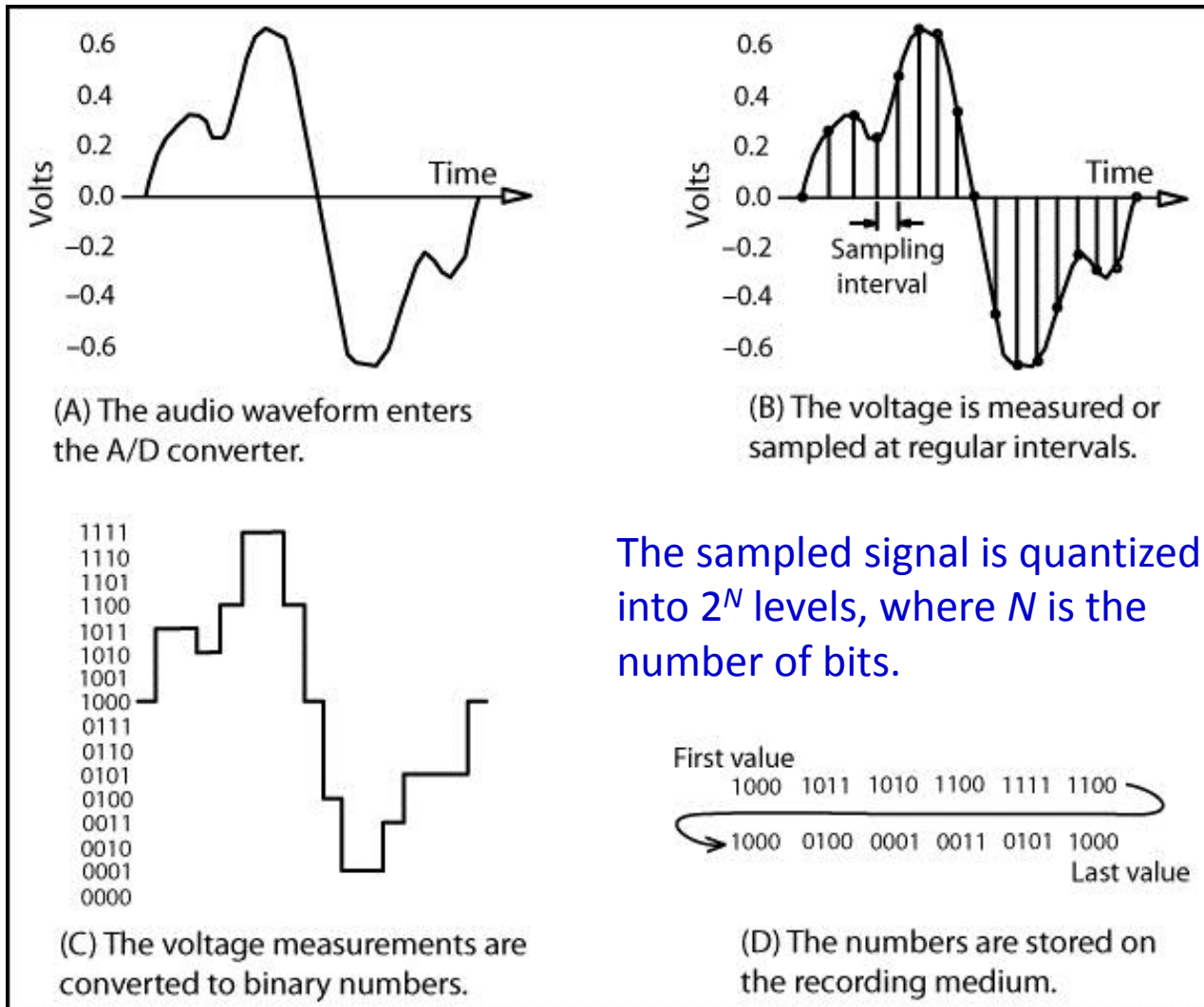
Digital Signals

A **digital signal** is a signal in which the original information is converted into a string of bits (binary digits) before being transmitted. Digital signals can be sent for long distances and suffer less interference than analogue signals.



ASK: Amplitude shift keying; **FSK:** Frequency shift keying; **PSK:** Phase shifting keying

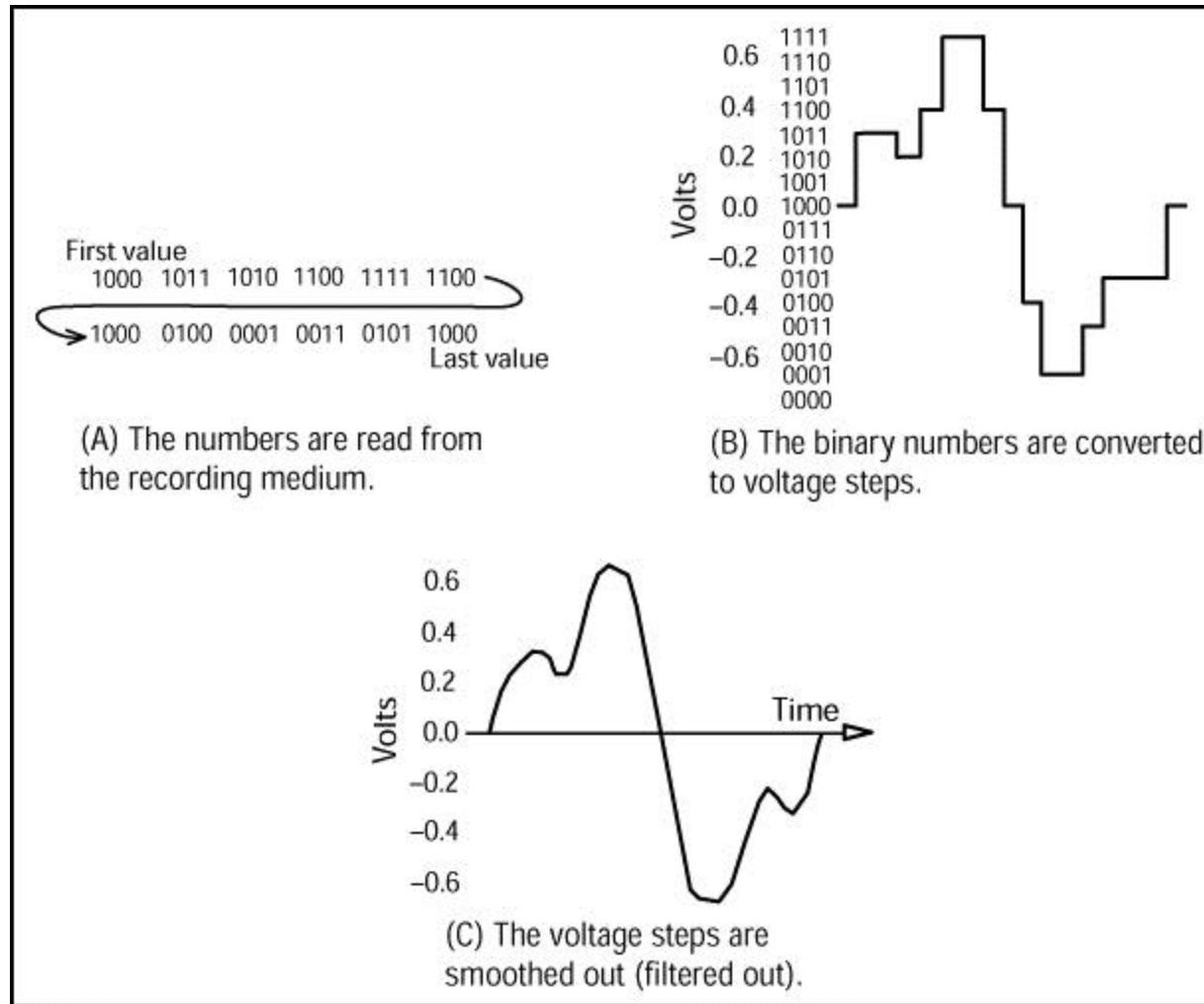
Analog-to-Digital Conversion



<http://archive.l2pnet.com/blogs/digital-recording-does-not-chop-your-music-11102010>

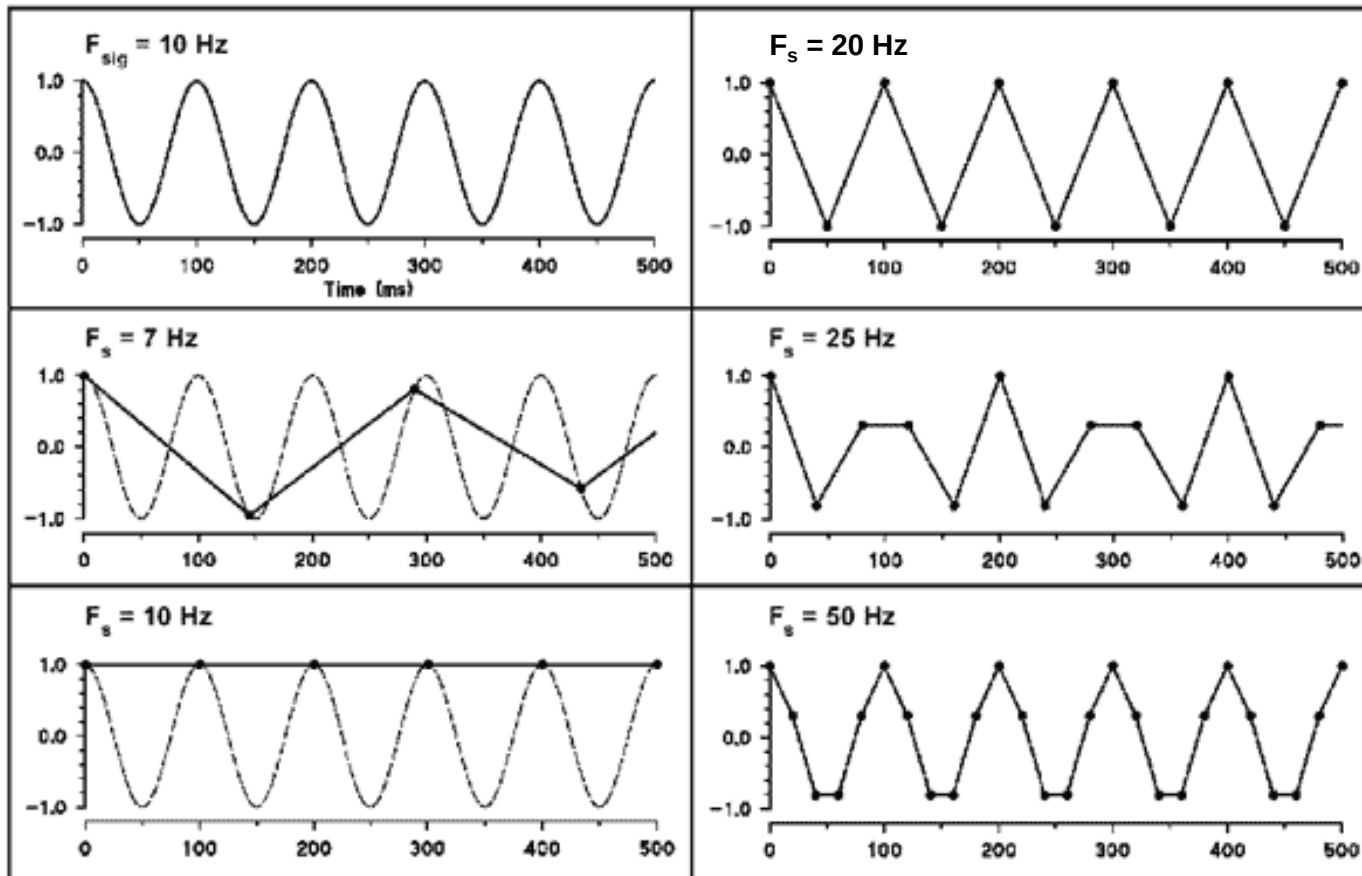
Animation: <https://www.youtube.com/watch?v=tZR7hLJx6Ms>

Digital-to-Analog Conversion



Nyquist Rate

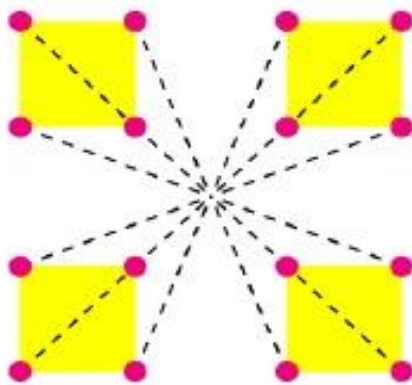
The minimum sampling rate for a band-limited signal is twice the highest frequency of the signal. This rate is referred to as the **Nyquist rate**.



Quadrature Amplitude Modulation (QAM)

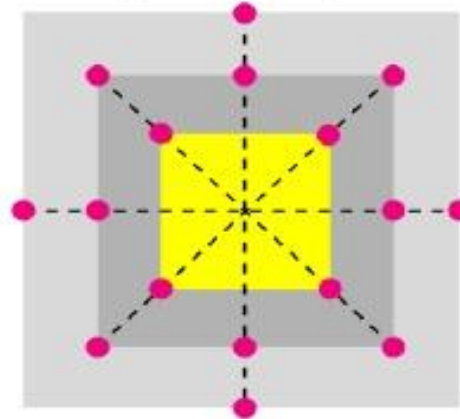
Quadrature amplitude modulation (QAM): The modulated waveform is a combination of both ASK and PSK. QAM is widely used in digital television systems and mobile communication systems. A variety of forms of QAM are available and some of the more common forms include 16-QAM, 32-QAM, 64-QAM, 128-QAM, and 256-QAM.

3 amplitudes, 12 phases



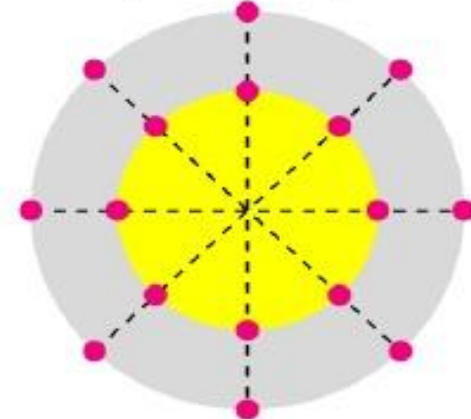
16-QAM

4 amplitudes, 8 phases



16-QAM

2 amplitudes, 8 phases



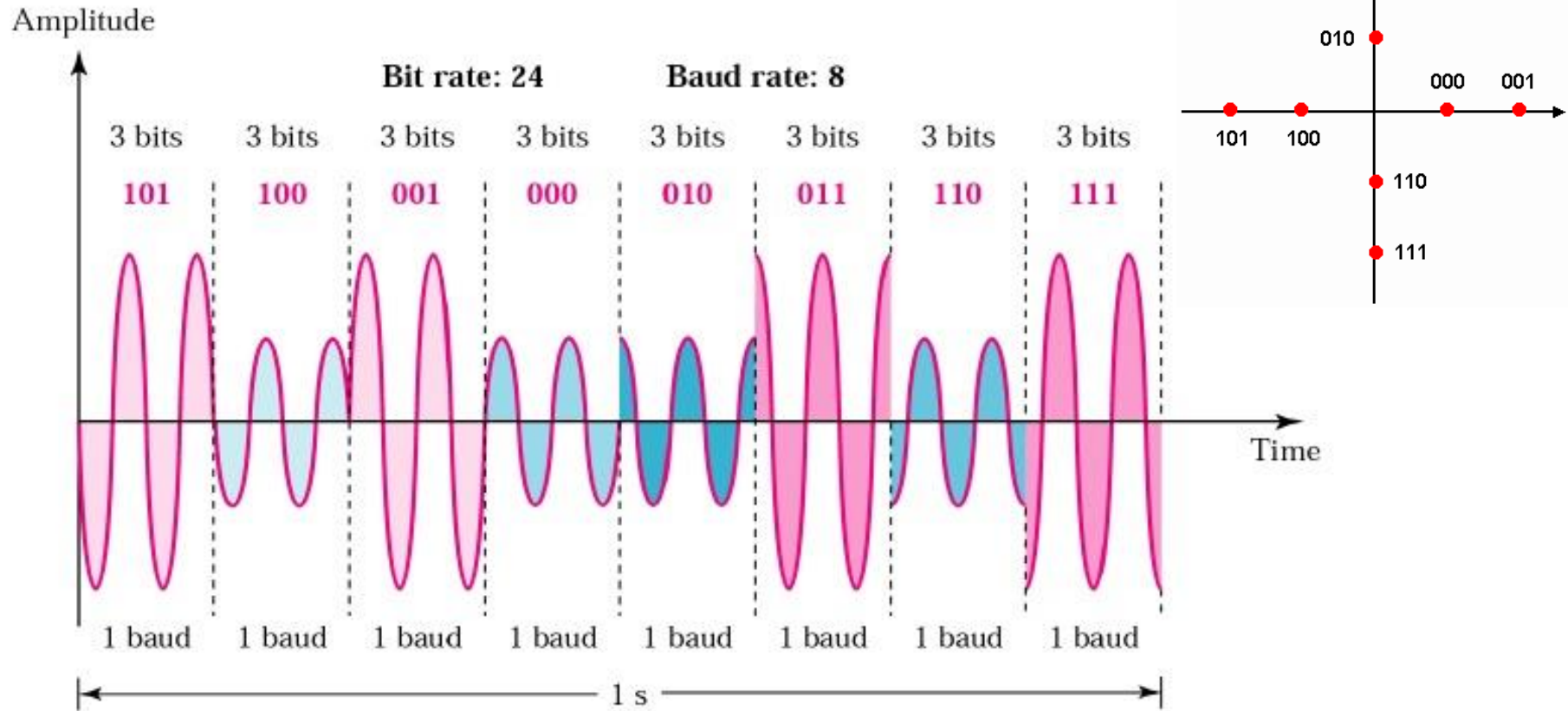
16-QAM

Constellation diagrams for 16-QAM.

<http://www.slideshare.net/soumya604159/ch-05>

Quadrature Amplitude Modulation (QAM)

8-QAM: 2 amplitudes; 4 phases



Bit rate: Number of bits per second

Baud rate: Number of signal units per second

<http://www.slideshare.net/soumya604159/ch-05>

Quadrature Amplitude Modulation (QAM)

Example:

Consider a digital transmission system that employs a 16-QAM scheme. The lowest and the highest frequency in the baseband analog signal to be digitized are 50 Hz and 3.33 kHz, respectively. The signals are sampled at 1.2 times of the Nyquist rate and each sampled signal is represented by 4 binary digits. What are the sampling rate, the bit rate, and the baud rate of the system?

Sampling rate = $1.2 \times 2 \times 3.33 \text{ kHz} = 8 \text{ kHz}$

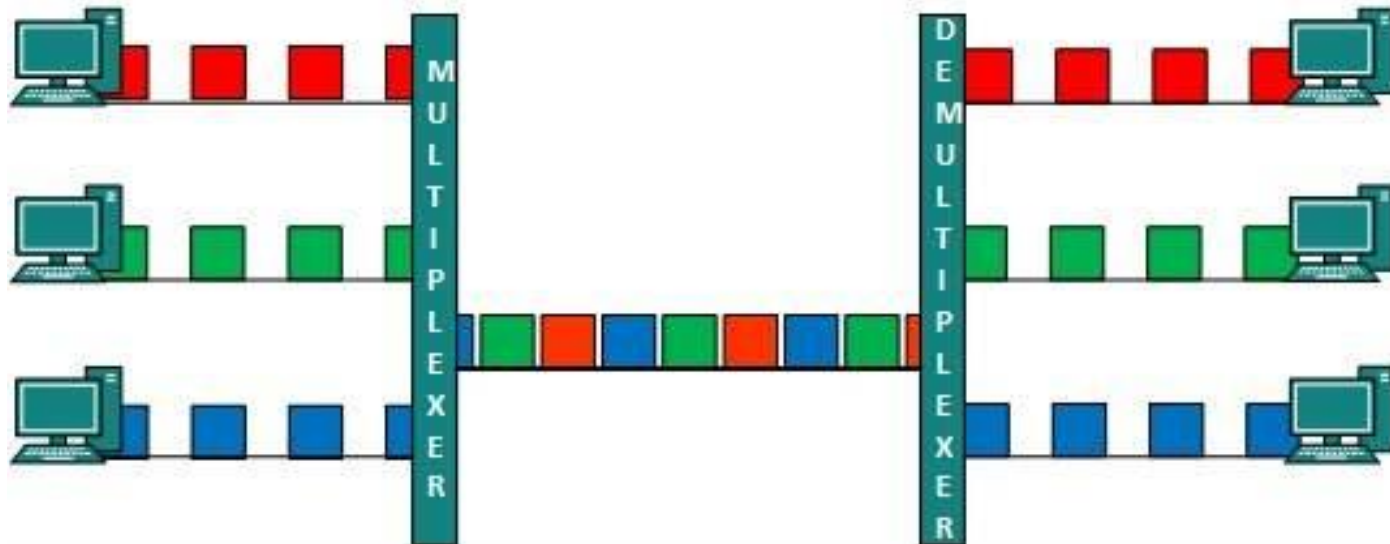
Bit rate = $8 \text{ kHz} \times 4 \text{ bits} = 32 \text{ kb/s}$

Baud rate = $32 \text{ kb/s} \div 4 = 8 \times 10^3 \text{ signal units/s}$ (Note: $2^4 = 16$)

Note: Signal rate can also be expressed as numbers of bytes per second, where 1 byte = 8 bits.

Time-Division Multiplexing (TDM)

Time-division multiplexing (TDM) is a digital technology which uses time to separate the different data streams. TDM involves sequencing groups of a few bits or bytes from each individual input stream, one after the other, and in such a way that they can be associated with the appropriate receiver. If done sufficiently quickly, the receiving devices will not detect that some of the circuit time was used to serve another logical communication path.



http://www.tutorialspoint.com/data_communication_computer_network/physical_layer_multiplexing.htm

Digital Television

A digital TV channel carries a 19.39-Mbit/s stream of digital data and can carry multiple sub-channels.

The reason that a broadcaster can create sub-channels is because digital TV standards allow several different formats. Broadcasters can choose between three formats:

480i - The picture is 704x480 pixels, sent at 60 interlaced frames per second (30 complete frames per second).

480p - The picture is 704x480 pixels, sent at 60 complete frames per second.

720p - The picture is 1280x720 pixels, sent at 60 complete frames per second. (Available in Hong Kong)

1080i - The picture is 1920x1080 pixels, sent at 60 interlaced frames per second (30 complete frames per second). (Available in Hong Kong)

1080p - The picture is 1920x1080 pixels, sent at 60 complete frames per second.

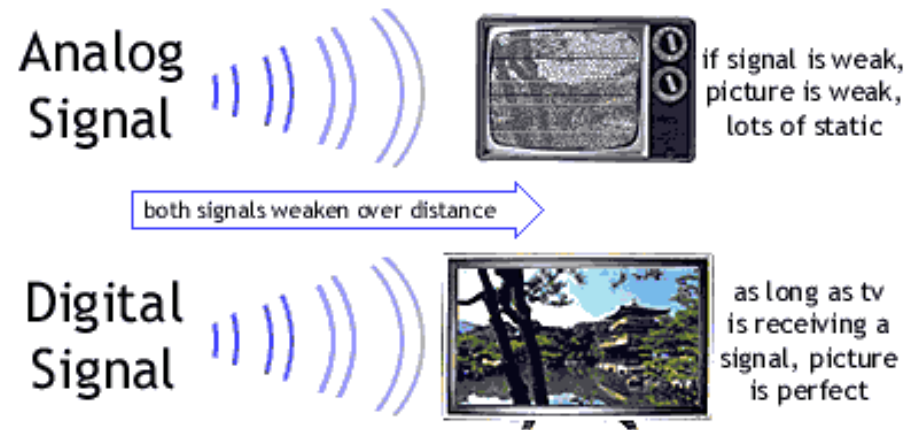
(The "p" and "i" designations stand for "progressive" and "interlaced." In a progressive format, the full picture updates every 60th of a second. In an interlaced format, half of the picture updates every 60th of a second.)

The 720p, 1080i, and 1080p formats are **HD (high definition)** formats.

An analog TV has a 4:3 aspect ratio, while an HD digital TV has a 16:9 aspect ratio.

Digital Television

Digital TV signals can be compacted using video compression technology, which allows more picture detail to be included in the signal. The Motion Picture Expert Group created a set of video compression standards called MPEG-2, which uses an algorithm to redraw only the changes in a video image rather than redraw the entire frame each second. Thus, digital TV can easily broadcast a high-definition image within the 6-MHz channel's range. Digital TV is not prone to data loss over distance like analog TV.



Hong Kong digital TV channels use **H.264** or **MPEG-4 Part 10, Advanced Video Coding (MPEG-4 AVC)**, which is a more efficient video encoding formats for the recording, compression, and distribution of video content.

5 Advantages of Digital TV Over Analog



The digital broadcast signal has numerous advantages over the analog signal that will aid television broadcasts in the present and help them prepare for the future.

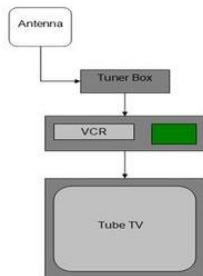
SIZE

Digital TV signals are much more compact than analog signals. This means they take up less space within the bandwidth, leading to more room for more stations in one region.



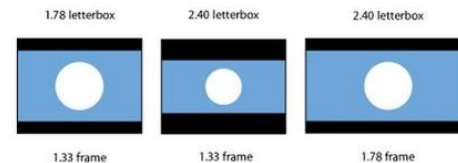
FUNCTION

Digital tuners remove any interference from the TV signals before converting them into the pictures and sounds, meaning there is no distortion like "static" or "snow" on the picture.



EFFECTS

Digital TV permits wider "letterbox" style image screens, meaning watching programs on TV sets will be closer to watching movies on screens.



HDTV



Digital TV allows for high-definition television, which means an even clearer, more realistic picture and higher quality sound.

FEATURES

Digital TV allows for high-definition television, which means an even clearer, more realistic picture and higher quality sound.

WWW.BESTONINTERNET.COM

Exercise

1. A digitized music signal for CDs has a sampling rate of 44.1 kHz. What is the highest frequency in the music signal that CDs can carry without losing fidelity?
2. A voice signal with a frequency spectrum varying from 300 Hz to 3.4 kHz is to be converted into a digital signal. What is the minimum rate at which the voice signal should be sampled? If the sampled signal is quantified into 4096 regular levels, how many binary bits will be needed and what will be the bit rate of the digitized signal?
3. Draw the constellation diagram for 4-QAM that consists of one amplitude and four phases (also known as QPSK – Quadrature Phase Shift Keying). Sketch the wave forms of the four states of the modulation scheme and label their binary representations. What is the number of bits per symbol?
4. A digital video signal is generated at 25 frames per second for full-screen displaying on a computer monitor that has a resolution of 640×480 pixels. Each pixel can have up to 256 colors. Calculate the bit rate of this video signal. If this video is played for 10 minutes, how large is the file size (in giga-bytes or GB)?